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An Analysis of Offshore Safety During Oil and Gas Operations on the Outer Continental Shelf

James H. Collins
University of Rhode Island

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**AN ANALYSIS OF OFFSHORE SAFETY DURING
OIL AND GAS OPERATIONS ON THE OUTER CONTINENTAL SHELF**

BY

JAMES H. COLLINS

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS
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MASTER OF ARTS THESIS

OF

JAMES H. COLLINS

APPROVED:

Thesis Committee

Major Professor

R. A. Burroughs
Chairman

John M. Clancy
Dane R. Kestel
DEAN OF THE GRADUATE SCHOOL

UNIVERSITY OF RHODE ISLAND

1988

ABSTRACT

Trends in offshore fatalities and lost time accidents since the Outer Continental Shelf Lands Act Amendments of 1978 need to be identified to allow an evaluation of the safety of offshore operations. Fatality and accident data between 1975 and 1985 are analyzed in the context of the Federal regulatory structure. The safety data generated for oil and gas drilling operations on the Outer Continental Shelf varies according to the source of the information. Modifications to accident reporting formats and data collection systems would benefit the offshore industry and the Government regulators in their efforts to improve operational safety. A major regulatory mechanism created to ensure that the best available and safest technologies are employed during Outer Continental Shelf drilling operations has not resulted in deepwater operations achieving a safety record as good as other offshore areas. The mandated economic considerations of this legislation appear to have allowed the letter of the law to be achieved without providing a commensurate improvement in offshore safety.

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The efforts made by Professor Burroughs on my behalf are sincerely appreciated. The difficulties of providing guidance from a distance of 400 miles are countless.

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Chapter 1

INTRODUCTION AND STATEMENT OF THE PROBLEM

Federal safety regulations promulgated to protect personnel and equipment during oil and gas drilling operations on the Outer Continental Shelf (OCS) do not address specific conditions associated with the evolution of emerging offshore technologies. The OCS Lands Act Amendments of 1978 established an equipment-oriented regulatory program.¹ It requires that the best available and safest technologies (BAST) be applied to OCS operations. The Amendments left primary responsibility for ensuring the safety of offshore operations to the oil and gas industry. A Federal safety policy that vests such responsibility with companies operating on the OCS appears to be desirable from an administrative standpoint. However, serious questions remain unanswered about the performance and accountability of the industry, especially in the face of excess supply of and lower prices for crude oil. A significant question to ask prior to addressing the policy issue is what trends in OCS operational safety can be identified in recent years?

Operational safety, for purposes of this analysis, is defined as the protection of life and limb during all phases of OCS drilling activities. Included are moving to and from the location and the physical act of drilling. The protection of life and limb will be examined over time by quantifying fatalities and accidents. The trends in safety issues that emerged between 1975 and 1985 will be analyzed. *now* The role of the Federal government in regulating OCS activities will

also be examined in terms of statutory intent and policy implementation.

SCOPE AND LIMITATIONS

The OCS Lands Act of 1953 provided for the jurisdiction of the Federal government over the submerged lands of the OCS, seaward of the state boundaries. The Act also authorized the Secretary of the Interior to lease such lands for certain purposes, including mineral exploration and development.²

The 1978 Amendments to the Act resulted from an attempt to resolve conflicts primarily associated with the Federal leasing program and its role in assuring the contribution of OCS energy resources to domestic supplies. The resulting OCS regulatory program was responsible for managing the nation's offshore mineral resources in a manner that best benefited the country in terms of addressing the promise and risk of developing OCS resources.

Under authority of the OCS Lands Act there are seven Federal agencies in four different departments that have regulatory authority over OCS drilling operations. The Department of Interior (DoI) and the Department of Transportation (DoT) are the two departments most involved in the rulemaking and enforcement of safety considerations from the standpoint of design, construction, installation, and operation of OCS facilities. Therefore, the previously stated problem will primarily be examined in terms of the applicable regulatory arms of the DoI and DoT. These are the Minerals Management Service (MMS) and the United States Coast Guard (USCG), respectively. The scope and limitations of the problem are generally contained within Sections 21 and 22 of the 1978 OCS Lands Act Amendments.³

Offshore oil and gas exploration and development takes place in areas under the jurisdictions of both Federal and state governments. The Federal government has exclusive jurisdiction at least 200 nautical miles seaward of the baselines used to calculate the coastal states' landward boundaries. States have jurisdiction for leasing mineral rights over the area 3 geographic miles from the established baselines. Exceptions to this are in the Gulf of Mexico, where Texas and Florida each claim a distance of 3 marine leagues. Much of the current exploration and development drilling activity occurs within Federal jurisdiction.

Government regulation of marine safety, in particular that related to offshore drilling operations, is part of a broad mandate to explore and develop offshore resources. Marine safety legislation in this context refers to statutes, regulations, orders, standards, or criteria, which demand compliance during offshore drilling operations. The principal objective of marine safety regulation is to protect lives and property.⁴

The actual implementation of the Federal government's OCS safety regulations involves the promulgation of regulations by the various agencies at the national level with occasional interpretative guidance at the regional levels to establish rules, procedures, and standards for OCS development. The implementation of regulations is affected by the technical capabilities of the government personnel administering them. The numerous agencies involved with duplicative and overlapping authorities and regulations have been criticized by the offshore industry for the confusion and cost burdens they create.

Recognizing the overlapping jurisdictions, the agencies have made use of negotiated Memorandums of Understanding (MOUs) to resolve conflicts, to enhance safety, and improve efficiency. The 1980 MOU between the MMS and the USCG recognizes the expertise of the MMS in regulating offshore drilling and production activities and the tradition and experience of the USCG in regulating maritime safety.⁵ For example, the USCG has responsibility for a mobile offshore drilling unit (MODU) as a vessel, while the MMS has responsibility for drilling operations undertaken from the MODU. The MMS and the USCG have also entered into interagency agreements with the other Federal agencies to administer various workplace safety regulations.⁶

No unified regulations governing workplace safety on the OCS presently exist. However, in 1986 MMS published proposed revisions to DoI offshore operating rules in the Federal Register.⁷ Included in the proposed changes were the consolidation of several separate regulatory requirements into a single document. Specific details of the proposed rulemaking will be examined later in this study. The USCG is also preparing a set of regulations under the authority of the OCS Lands Act, as amended, to address offshore workplace safety problems.⁸ The USCG regulatory authority applies to the safety of life and property governing offshore operations and makes frequent reference to industry standards and recommended practices. The history of offshore oil and gas operations follows safety and technological improvements initiated by the commercial sector, and their standards and recommended practices have often been incorporated into regulations.⁹

The 1978 OCS Lands Act Amendments also established a potential focusing mechanism for the Federal OCS safety regulatory program.¹⁰

Section 21(b) of the Amendments called for the Secretary of the Department of the Interior, and the Secretary of the Department in which the Coast Guard is operating (currently the DoT), to require on all new drilling and production operations and wherever practical on existing operations, the use of the best available and safest technologies wherever failure of equipment would have a significant effect on safety, health, or the environment. The equipment must be determined economically feasible. Exceptions are made where the incremental benefits are clearly insufficient to justify the incremental costs of utilizing the technologies.¹¹ The BAST requirement has the potential capacity to better ensure the adequacy of regulations that provide for OCS safety. The intent is to standardize certain pieces of operational equipment in order to reduce the number of accidents that occur as a result of equipment failure or the lack of familiarity of personnel with the equipment due to the large number of alternative technologies in use. The legislative history of the BAST requirement will be examined and the conceptual issues leading to its codification will be discussed. In addition, the question of how successfully the Federal government has regulated innovative offshore technologies since 1978 will be addressed in this study. The MMS is presently implementing a BAST program on agency, national, and regional levels while the USCG is still in the process of developing its BAST program.

Section 21(b) of the 1978 Amendments also defined the scope of what facilities are to be regulated by referring to Section 4(a)1 of the OCS Lands Act which extended Federal jurisdiction to include artificial islands and all installations and other devices permanently or temporarily attached to the seabed.¹²

Section 22(a) states that MMS and USCG have enforcement authority over safety regulations.¹³ The Department of Labor, Occupational Safety and Health Administration's (OSHA) rules will be considered only as supplementary because most of them are not offshore-specific.

Hypotheses

Two hypotheses will be tested in this analysis:

1. Historical trends in OCS operational safety indicate that the requirements of the Outer Continental Shelf Lands Act Amendments of 1978 have improved the safety of offshore operations.
2. Implementation of the best available and safest technologies requirement has not resulted in deepwater drilling operations achieving improvements in safety that are as good as other offshore areas.

Methodology

The following assumptions were made in establishing a methodology to test the hypotheses: (1) The exploratory drilling phase of OCS operations accounts for a disproportionately large share of safety concerns in offshore operations; (2) the current status of domestic OCS activities in deepwater and other frontier areas is largely in the exploration stage; (3) because of competition, it is difficult for a regulatory body to maintain a staff with sufficient technical knowledge of OCS facilities and operations to adequately assess equipment-

oriented safety issues; and (4) declining crude oil prices and corporate mergers generally tend to have a negative effect on exploration budgets and increases the uncertainty of the industry's ability to maintain an adequate level of safety through worker motivation and training. Oil spills and their associated impacts to the environment will be not be included in this research. The analysis that follows the presentation of the accident data will examine the problems faced by the industry that develops the various exploratory technology and the regulators involved in the determination of BAST.

In addition to the OCS Lands Act, as Amended, the Section 21(a) Report mandated by the Amendments and the National Research Council (NRC) Marine Board's study, "Safety and Offshore Oil," are central to this analysis.¹⁴ The NRC study was originally requested by the DoI, U.S. Geological Survey Conservation Division, in order to determine specific topics to be addressed in the Section 21(a) Report. However, "Safety and Offshore Oil" was such a comprehensive effort that the Section 21(a) Report was simply a series of responses to several of the many recommendations offered by the Marine Board. The NRC report determined that the OCS regulatory system is not designed to take the best advantage of the entire industrial management structure to motivate concern for safety on every level. As currently constituted, the Federal program is generally comprised of regulations that are based on the premise that if the law commands, operators will obey and that inspection will therefore ensure compliance. The report included a recommendation that Federal agencies incorporate alternative techniques into the regulatory system to better utilize the potential of the industrial management structure in promoting safe worker performance.¹⁵

The 1981 NRC report also indicated that regulations do not comprehensively address the subject of worker training and qualification with regard to workplace safety. Regulations have been much more successful in applying new technologies rather than in ensuring that workers, particularly those at the entry-level, are properly trained in safe practices. This lack of properly trained workers was found to be a common weakness throughout the offshore industry. The NRC study concluded that workplace safety on the OCS is not easily improved by legislation or detailed regulations. It found that during drilling operations, workers with less than a year on the job account for more than 75 percent of lost time accidents, and that more than half of these injuries occur within the first 6 months of employment.¹⁶

The final sentence of Section 21(a) of the 1978 Amendments directs the President, in light of the findings in the above mentioned reports, to submit a plan to Congress with his proposals to formulate a Federal safety policy for mineral resource extraction operations on the OCS.¹⁷ Some of the responses to recommendations contained in the Section 21(a) Report are now being implemented through the regulatory process.¹⁸ However, this research does not lend itself to a determination of the adequacy of an emerging, but still ambiguous Federal safety policy. A significant issue to be considered is whether recent trends in accident frequencies point to successes or failures in regulatory efforts to increase offshore safety.

The 1984 NRC Marine Board Study, "Safety Information and Management of the OCS," and the 1985 Office of Technology Assessment Study, "Oil and Gas Technologies for the Arctic and Deepwater," which examine concerns resulting from the rapid advances recently made in

frontier technologies on the OCS and their associated interaction with safety regulations will also be used as references in this analysis.¹⁹ Determining the applicability of existing safety regulations to the innovative technologies being developed in previously unexplored areas is a timely topic. Assessing the adequacy of the procedures that Federal regulators employ to decide which technologies are considered BAST is a subject worthy of continued study.

OCS operational safety data gathered from the International Association of Drilling Contractors (IADC), for the period of 1975 through 1985, will be analyzed.²⁰ Lost time accidents (LTA) and fatalities will be presented as frequency rates. The data will be normalized per man hour in order to indicate the relative level of offshore activity that occurred during the period of record. Also available are data from the MMS Safety Information Program events file and the Coast Guard Marine Safety Office accident reporting system.²¹ These programs contain some equipment-specific data that will allow for a discussion of some of the casual factors that contributed to the trends in OCS safety during the past 10 years.

Once the first hypothesis concerning safety trends has been addressed, the second hypothesis will be discussed to determine cause and effect relationships of the BAST requirement. The implementation of BAST will be assessed by using deepwater Gulf of Mexico data as a surrogate for the "innovative technology" that would have required BAST development. A discussion of current safety regulations and their legislative history will be included in Chapter 2. The pertinent literature will also be considered in this chapter. Presentation and

analysis of OCS operational safety data will be addressed in the following chapter beginning with the IADC accident statistics. Data collected through the MMS regulatory regime and under authority of the USCG will also be included in Chapter 3, along with oil price information. A final chapter will evaluate recent trends in offshore safety and discuss the relationship between Federal OCS safety policy and accident rates. The OCS safety issue will also be examined in the broader context of the long-standing policy question of how government can best manage ocean issues. A discussion of the basic rotary drilling concept used on the OCS is provided in Appendix I to aid the reader in understanding some of the technologies needed to drill offshore wells. A description of how some of the frequently occurring accidents typically happen is also included.

Notes

1. Outer Continental Shelf Lands Act Amendments of 1978, U.S. Code, Title 43, Sections 1801 et. seq.
2. Outer Continental Shelf Lands Act, U.S. Code, Title 43, Sections 1331 et. seq.
3. 43 U.S.C. 1347-1348, Sections 21 and 22 refer to the language contained in Public Law 95-372 (92 STAT.654-657), September 18, 1978.
4. Federal statutory legislation is vested in Title 33 of the United States Code of Federal Regulations (Navigation and Navigable Waters) and Title 46 (Shipping). These set out the original regulations that applied to offshore activities. In addition, the 1953 OCS Lands Act and the 1978 Amendments provided a mechanism

for the DoI and the DoT to promulgate and enforce additional regulations related to offshore drilling activities. These are established in Title 30 (Operations) as well as Title 43 (Rule-making) and additions to Title 46.

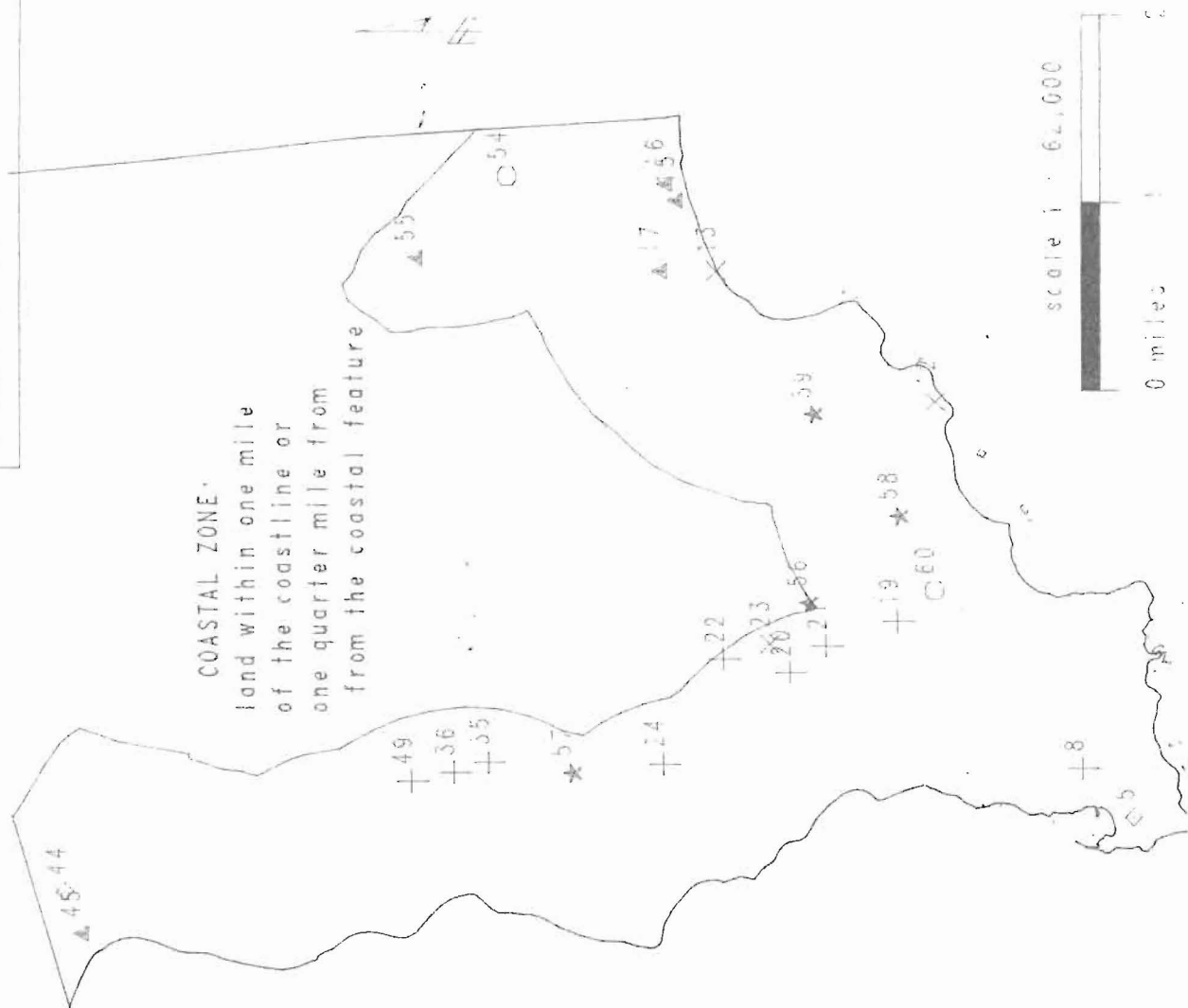
As many as 18 Federal agencies have an active interest in regulating some aspects of OCS operations in the United States. Of the seven agencies that have statutory authority to regulate drilling activities on the OCS, the two principal departments that administer the majority of offshore safety legislation are, as previously mentioned, DoI and DoT. The departments and their agencies are as follows:

- Department of the Interior (DoI)
 - Bureau of Land Management (BLM)
 - U.S. Geological Survey (USGS)
 - Minerals Management Service (MMS)
- Department of Transportation (DoT)
 - U.S. Coast Guard (USCG)
 - Federal Aviation Administration (FAA)
- Department of Labor (DoL)
 - Occupational Safety and Health Administration (OSHA)
- Department of Defense (DoD)
 - U.S. Army Corps of Engineers (USACE)

5. K.V. Feeney, "The Coast Guard's Offshore Safety Program," paper prepared for distribution at the Offshore Technology Conference, Houston, TX, 1985, p. 7 (typewritten).

Land Ownership

- + SAKONNET PRESERVATION ASSN.
- * LITTLE COMPTON AC. CONSERV.
- ▲ THE NATURE CONSERVANCY
- C AUDUBON SOCIETY OF RI
- X TOWN OF LITTLE COMPTON
- ◇ STATE OF RHODE ISLAND



6. These agreements include those dealing with FAA heliport requirements and certain OSHA rules that are not offshore-specific; therefore are not within the scope of this research.
7. U.S. Department of the Interior/Minerals Management Service, "Oil and Gas and Sulphur Operations on the Outer Continental Shelf (OCS)," Federal Register 51, No. 52, March 18, 1986, 9316-9425.
8. 43 U.S.C. 1347-1348.
9. Traditionally, organizations such as the American Bureau of Shipping, the American Petroleum Institute, and the American National Standards Institute/American Society of Mechanical Engineers have published specifications that are adopted as OCS Orders. For example, Gulf of Mexico OCS Order No. 5, Production Safety Systems, Section 3.2, states, in part, that "...subsurface-controlled subsurface safety values...shall conform to American Petroleum Institute (API) Specifications for Subsurface-Safety Values API Spec. 14A, Fourth Edition, November 1979...". From: United States Department of the Interior/Minerals Management Service, Gulf of Mexico Outer Continental Shelf Orders Governing Oil and Gas Lease Operations, January, 1980, p. 5-3.
10. 43 U.S.C. 1347 (b).
11. Ibid.
12. Section 21(b) of the OCS Lands Act Amendments of 1978, Public Law 95-372 (92 STAT.655), as codified in 43 U.S.C. 1347(b).
13. Section 22(a) of the OCS Lands Act Amendments of 1978, Public Law 95-372 (92 STAT.655), as codified in 43 U.S.C. 1348(a).
14. 43 U.S.C. 1331-1356, The Section 21(a) Report was the result of the "Study" mandated by 43 U.S.C. 1347(a), entitled "Joint Report

by United States Coast Guard and Minerals Management Service on OCS Safety and Health Regulations and Technology Pursuant to Requirements in Outer Continental Shelf Lands Act Amendments of 1978," Reston, VA, 1983 (typewritten), hereafter referred to as the Section 21(a) Report in the text; Safety and Offshore Oil, Report of the Committee on Assessment of Safety of Outer Continental Shelf Activities, Marine Board Assembly of Engineering, National Research Council, by George F. Mechlin, Chairman (Washington, DC: National Academy Press, 1981).

15. National Research Council, Safety and Offshore Oil, pp. 243-244.
16. Ibid.
17. 43 U.S.C. 1347(a).
18. For example, the Coast Guard revised the casualty reporting requirements of 33 CFR 146 and various parts of 46 CFR in response to a recommendation that the collection of workplace data be strengthened. The Marine Board recommendation and response to it are found in the "Section 21(a) Report," pp. 26-28.
19. Safety Information and Management on the Outer Continental Shelf, Report of the Committee on Outer Continental Shelf Safety Information and Analysis, Marine Board Commission on Engineering and Technical Systems, National Research Council, by Hyla S. Napadensky, Chairman (Washington, DC: National Academy Press, 1984); Oil and Gas Technologies for the Arctic and Deepwater (Washington, DC: United States Congress, Office of Technology Assessment Report OTA-O-270, 1985).

20. The basic data were obtained by mail from the International Association of Drilling Contractors in Houston, Texas. The information was available in annual Accident Safety Statistics Reports consisting of a series of exhibits that classified injuries, fatalities, and related data. The presentations generally became more detailed over time. The use of graphs began with the 1984 data. However, the data used in this analysis was collected and presented in a consistent manner throughout the period of study.
 21. The data from the MMS events file were obtained in person at the United States Geological Survey National Headquarters Building in Reston, Virginia. The information was made available via a special request for a computer run to the Minerals Management Service, Division of Offshore Operations. The totals were manually verified by telephone to ensure that a thorough data run had been completed; the Coast Guard data were obtained by mail from the Marine Investigation Division, Washington, DC. The information was provided following a written request to the Chief of the Marine Safety Evaluation Branch.
- The data obtained from both agencies is considered to be the most accurate publically available safety information. However, both data files have similar weaknesses that will become apparent in Chapter 3. The deficiencies are due to fundamental changes in reporting systems and data collection formats. Some were simply technological advances and others were due to regulatory change. The result is that historical analysis is difficult and the value of the agency data bases are limited.

Chapter 2

LEGISLATIVE HISTORY AND REGULATORY STRUCTURE

The oil industry had been moving offshore for nearly half a century when the 1945 Truman Proclamation arrested further development at the state level by asserting that the Government of the United States regards the natural resources of the subsoil and seabed of the Continental Shelf beneath the high seas but contiguous to its coasts as appertaining to the United States, subject to its jurisdiction and control. Truman made mention in the first paragraph of the proclamation that the United States is aware of the long range world-wide need for new sources of petroleum and other minerals, and holds the view that efforts to discover and make available new supplies of these resources should be encouraged.¹

The Submerged Lands Act of 1953 effectively reversed a decision of the U.S. Supreme Court by granting the states title to and ownership of the lands beneath the navigable waters seaward of their coastlines to a distance of three geographical miles, with the additional opportunity to prove title out to three marine leagues (approximately 10.35 statute miles) into the Gulf of Mexico.² Florida and Texas have taken advantage of this provision, whereas all other coastal states and the Atlantic coast of Florida have their seaward boundaries set at the three geographical mile line. The Act allowed for continuance of oil industry development on state-leased lands that petroleum was being produced from on or before December 11, 1950, and established other provisions for lease terms that were executed by states and which were in force and effect on June 5, 1950. The Act also retained

Federal powers regarding navigation, commerce, and national defense, as well as preserving Federal ownership and control of the submerged lands lying seaward of the belt granted the coastal states.³

The 1953 OCS Lands Act reaffirmed that those lands beyond the three geographical mile limit appertain to and are subject to the jurisdiction, control, and power of disposition of the Federal Government, and authorized the Secretary of the Interior to grant mineral leases on OCS lands and to prescribe such regulations as might be necessary to carry out the provisions of the Act.⁴ Thus, the Act designated the DOI to administer the mineral leasing of the offshore areas of the United States under Federal jurisdiction.

Until January of 1982, the Department had delegated responsibility for the regulation of all OCS oil and gas operations to the USGS Conservation Division. The USGS issued regulations for oil and gas operations on a national or regional basis, as appropriate. The regulations emphasized the safety of operations, the protection of life and property, and the prevention of pollution.

Former DOI Secretary James Watt established the MMS on January 19, 1982, with Secretarial Order (SO) 307-1.⁵ The creation of MMS represented an effort by DOI to increase financial efficiency through better royalty management practices and was created in response to recommendations of the "Commission on Fiscal Accountability of the Nation's Energy Resources."⁶ The action initially consisted of the consolidation of the Conservation Division of the USGS, the Offshore Leasing Management Agency of BLM, and a portion of the Office of OCS

Policy Coordination (POCS). Amendments 1 and 2 to SO 307-1 consolidated the remainder of POCS, as well as giving all OCS leasing activities to MMS and establishing the necessary administrative functions and procedures to run the offshore program.⁷ The procedures and responsibilities of MMS regarding offshore safety regulations remain essentially the same as those under the USGS Conservation Division. For purposes of clarity and consistency, the acronym MMS will be used when discussing DOI regulatory functions since the 1953 OCS Lands Act, although prior to 1982 the actual responsibility lay with the USGS.

MMS is responsible for issuing and updating OCS Orders under 30 CFR parts and 250 and 256.⁸ The orders are issued by the Director of MMS to implement the requirements of the regulations and have the force of law, therefore operators must comply with them just as they must comply with the Regulations. Because of the detailed nature and comprehensive scope of the Orders, the potential for noncompliance is high. Enforcement is the responsibility of MMS District Supervisors. Therefore, the districts also issue Notices to Lessees (NTL). An NTL is usually a regional notification that clarifies or interprets a regulation, order, or lease sale stipulation. OCS operators are required to conduct inspections and tests of equipment and facilities at specified intervals and certify that the inspections were carried out and appropriate corrective measures taken. Unannounced compliance inspections by MMS personnel, in addition to the operator's inspections, are conducted twice a year. MMS employs full-time inspectors who are specialists in drilling or production operations. Checklists containing requirements of the Regulations and OCS Orders serve as a basic

inspection guide. Although NTLs are useful for clarification of Regulations and Orders, they are also a potential source of dispute if they are used as a means of promulgating additional regulations outside of the rulemaking procedures mandated by legislation. A list of active NTLs as of December 1985 is included at Appendix II.

Because of its relative maturity in terms of OCS operations, the following discussion of the OCS regulatory structure is referenced to the Gulf of Mexico unless otherwise specified. The current body of MMS regulatory requirements that relate to operations safety during OCS drilling activities are discussed in the following section.

As previously mentioned, the laws that provided the primary authority to establish the present OCS regulatory regime are the OCS Lands Act, NEPA, CZMA, and the OCS Lands Act Amendments.⁹ The final rules adopted in 30 CFR 250, Oil and Gas and Sulfur Operations in the outer Continental Shelf, contain several elements of the OCS Safety Program.¹⁰

Section 250.2 provides definitions, used throughout the code, that are applicable to the entire discussion of OCS safety. The definition of "Drilling Operations" means actual operations including the physical penetration of the seafloor for the purpose of creating a borehole, testing activities to demonstrate the capability of a well to produce oil or gas, and the completion operations needed to make a well physically able to produce oil or gas, or both.¹¹ The distinction of "physical penetration of the seafloor" is significant for determining the division of regulatory responsibility. For example, as mentioned in Chapter 1, MMS has jurisdiction over a semisubmersible drilling rig only during the time it is in actual physical contact with the seabed.

"Exploration" means the process of searching for minerals. Exploration activities include, but are not limited to: (1) Geophysical surveys where magnetic, gravity, seismic, or other systems are used to detect or imply the presence of such minerals; and (2) any drilling, whether on or off a known geological structure. Exploration also includes the drilling of a well in which a discovery of oil or natural gas in paying quantities is made and the drilling of any additional well, after a discovery, which is needed to delineate a reservoir and to enable the lessee to determine whether to proceed with development and production.¹² The significance for this discussion is the fact that many of the OCS regions that are experiencing technological advances are the same areas that are primarily in the exploration stage. There should be a direct relationship between operations in these areas and the development of alternative technologies requiring Best and Safest Technologies (BAST) determinations to be made. Although it took place prior to the codification of BAST, the regulation requiring the installation of subsurface safety valves provides a good example of how such a relationship could be developed for making BAST determinations, and is actually a precursor of BAST. Subsurface safety valves were introduced commercially in 1954, and until 1973 development of the technology was driven primarily by economics, which resulted in continued technological improvements but not in universal application. However, OCS Order Number 5-3, established in 1973, required that subsurface safety valves be installed on all producing wells. This resulted in rapid application of the technology to all relevant OCS operations and has sustained an economic climate conducive to continuing refinements and improvements of the technology.¹³

The jurisdiction and function of the MMS BAST Program is outlined specifically in the regulations, whereby the MMS Director is to: Require on all new and, whenever practicable, on existing drilling and production operations (including the construction and operation of platforms and pipelines), the use of the best available and safest technologies which the Director determines to be economically feasible, wherever failure of equipment would have a significant affect on safety, health, or the environment, except where the Director determines that the incremental benefits are clearly insufficient to justify the incremental costs of utilizing such technologies.¹⁴

Currently, OCS Order Number 5 officially implements the MMS Gulf of Mexico Region's BAST Program. The Order sets out requirements for the design, installation, and operation of subsurface safety devices, surface safety systems, and safety device testing and training on all platforms and structures located on the leased area. However, the actual process by which BAST is carried out is far less clear and is subject to a great deal of interpretation by all parties. Phrases such as "encouraged to continue the development of..." and "may be used..." in the following excerpts from Gulf of Mexico OCS Order Number 5 indicate the degree to which the MMS BAST requirement is still in the early stages of its evolution:

1. Use of Best Available and Safest Technologies (BAST). The lessee is encouraged to continue the development of safety-system technology. As research and product improvement results in increased effectiveness of existing safety equipment or the development of new equipment systems, such equipment may be used and, if such technologies provide a significant cost effective incremental benefit to safety, health, or environment, shall be required to be used if determined to be BAST.

Conformance to standards, codes, and practices referenced in this Order will be considered to be the application of BAST. Specific equipment and procedures or systems not covered by standards, codes, or practices will be analyzed to determine if the failure of such would have a significant effect on safety, health, or the environment. If such are identified and until specific performance standards are developed or endorsed by the U.S. Geological Survey (USGS), and as directed by the Supervisor on a case-by-case basis, the lessee shall submit information necessary to indicate the use of the BAST, the alternatives considered to the specific equipment or procedures, and the rationale why one alternative technology was considered in place of another. This analysis shall include a discussion of the costs involved in the use of such technology and the incremental benefits gained.¹⁵

The MMS Certification Requirement used to determine that the operator is employing BAST takes the form of endorsements included in exploration and development plans. The lessee is required to state that BAST is to be employed. BAST is in use if the lessee adheres in all respects to OCS Orders, or has MMS approval for specific items of noncompliance.¹⁶

The effectiveness of this type of implementation strategy appears to be limited by the capability of MMS personnel to successfully assess the technologies in question. The following discussion of how the BAST requirement has evolved and how it was originally intended may help to determine if this is the case.

Background of the BAST Requirement

Concern over the adequacy of Federal regulatory procedures to govern oil and gas operations on the OCS in a safe and efficient manner caused Congress to include several related safety provisions in the 1978 OCS Lands Act Amendments. The Section 21(b) mandate for a program to assure that technologies be continuously and systematically reviewed

in order that BAST are applied to OCS operations was coupled with a study requirement in Section 21(a) of the Act that stated:

Upon the date of enactment of this section, the Secretary and the Secretary of the Department in which the Coast Guard is operating shall, in consultation with each other and, as appropriate, with the heads of other Federal departments and agencies, promptly commence a joint study of the adequacy of existing safety and health regulations and of the technology, equipment, and techniques available for the exploration, development, and production of the minerals of the outer Continental Shelf. The results of such study shall be submitted to the President who shall submit a plan to the Congress of his proposals to promote safety and health in the exploration, development, and production of the minerals of the outer Continental Shelf.¹⁷

The so-called Section 21(a) Report was eventually presented to the President in 1984 as a response to an assessment of the adequacy of regulations and technologies on the OCS entitled, "Safety and Offshore Oil," that was published in June 1981 by the Marine Board, acting for the National Research Council (NRC).¹⁸

Prior to the release of either of the above mentioned reports, MMS had requested that the NRC suggest a strategy for the agency to use in carrying out its new responsibilities under the 1978 OCS Lands Act Amendments. In that strategy, issued in December 1978, the Marine Board cautioned that "Because different technologies may be necessary in different situations...there are no best available and safest technologies for universal application to all offshore oil and gas development operations."¹⁹ Accordingly, the Marine Board observed that it was not incumbent and, indeed, has not been the practice of MMS or the USCG to specify through regulation, a particular technology or technologies as the "best and safest" to be in compliance with the statute. This was reiterated in the Federal Register Notice of April 9, 1986, where

MMS states that they "Will not be certifying any technology, equipment, or procedure as the best available and safest."²⁰ During the comment period, MMS solicited information and details on new technologies that would "assist in the safe and expeditious exploration and development of the leasable minerals of the OCS."²¹ The comments were solicited for technologies that were considered by MMS to include equipment and/or procedures. The information received by MMS was to be used to ensure that the agency is aware of currently available technologies and that BAST is being reflected in their regulations. A significant question to consider is whether or not MMS is fulfilling the legislated intent of the BAST requirement by employing this methodology to determine the adequacy of their regulations. To address this question, the role of the Section 21(a) Report must be examined in its relationship to the development and implementation of BAST.

Timing of the Section 21(a) Study

Section 21(a) called for the study to be commenced promptly upon the date of enactment of the amendments to the law.²² Although Congress had presumably intended that the study be undertaken within a reasonable amount of time, the 1978 OCS Lands Act Amendments did not specify a completion date for the report. A rough indication of the amount of time considered necessary to complete the study can be found in H.R. 1614, introduced in January 1977 by Representative John Murphy of New York whose version of the OCS bill assigned the study to the National Academy of Engineering, and provided that the results be submitted "not later than nine months after the date of enactment..."²³ That the study and resulting regulatory plan precede implementation of the BAST requirement was implicit in H.R. 1614. It was argued that,

without the results of the study, the balancing of relevant economic factors used in the process of determining BAST could be considered too lightly and thereby introduce additional bias into the study. More importantly, premature implementation of Section 21(b) would not improve the "bureaucratic nightmare" of uncoordinated Government action the House OCS Committee intended to relieve by requiring the study.²⁴ The legislative history clearly shows that a sequential application of Section 21(a) followed by Section 21(b) was intended by Congress. However, such a mandate was not explicitly stated in the Amendments as they were finally enacted.

Also of significance to the issue of timing is the fact that the scope called for in the study reached far beyond the application of BAST. In fact, because the BAST requirement was primarily intended to be incorporated into the existing regulatory framework, it could usually be implemented by simply issuing procedural rules rather than promulgating entirely new regulations. Where this was possible, Subsection 21(b) would be implemented as soon as BAST procedures and determinations were made while, at the same time, the importance of the study could be recognized if, after initial BAST application, the incremental implementation was effectuated in logical and easily identifiable instances which had been sufficiently studied.²⁵

Participants in the Study

Subsection 21(a) stated that the MMS and the USCG will be the agencies directly responsible for the study. A provision for "Consultation with each other and, as appropriate, with the heads of other Federal departments and agencies..." was included.²⁶ However, because no other Federal agencies had substantive responses to the call for

comments on the assessment, "Safety and Offshore Oil," the content of the report was confined to the responses of the MMS and the USCG and consisted of a series of papers written by appropriate members of the task group selected for their particular expertise, background, and knowledge of the OCS regulatory process.²⁷

The question of who was to participate in the report preparation is further clouded by the rather vague language used in the Amendments. Early versions of the Senate bill included the DoL, more specifically OSHA, to participate in the generation of the study.²⁸ The "joint study" called for in Section 21(a) is subsequently referred to as "such study," which raises the question of what was intended: a single document produced by MMS and USCG personnel working together, or a concurrent effort by each agency to produce a study of issues under the purview of their respective jurisdictions? The adjectives "joint" and "such" seem to indicate a single study produced by both agencies, although it then seems redundant to specifically require that the MMS and the USCG consult with each other if only one study was intended. In any case, the product was a single study, in which some responses represent a single agency and others are joint MMS and USCG responses.

Regardless of the legislated intent of Section 21(a) as to who the participants in the study were to be, it appears that the MMS and the USCG performed their mandated functions satisfactorily. On June 5, 1981, the NRC completed its assessment and published "Safety and Offshore Oil" which provided the foundation of the Section 21(a) Report.²⁹ On June 25, 1981, a request for comments was published in the Federal Register³⁰. It announced the completion of the NRC assessment and requested comments from the public, industry, state governments, and

interested parties on the following concerns: technological development, human element, information, research, and environment.³¹ Then, during September of 1981, copies of "Safety and Offshore Oil" and the Federal Register Notice were sent to the Federal agencies that DoI thought might be interested in the Marine Board Study. When the comment period ended, only 20 comments had been received, resulting in the following mix of interested parties:³²

Oil and Gas Industry	- 12
Pipeline Industry	- 3
Maritime Industry	- 1
Environmental Interest	- 2
Individuals	- 1

As previously mentioned, there were no substantive comments received from Federal agencies. In fact, the only response was from the USACE who stated that they would concur with whatever comments were made by the USCG. Through this action, the MMS and the USCG had fulfilled the mandate of consulting with the heads of other Federal departments where appropriate.

Organization of the Section 21(a) Report

The NRC assessment, "Safety and Offshore Oil," is divided into a number of topical areas in which individual concerns are discussed in detail. At the end of each discussion, there is a section entitled, "Findings" or "Findings and Recommendations." The MMS and USCG task group charged with producing the Section 21(a) Report based its findings on the content of these sections in "Safety and Offshore Oil." The following discussion summarizes the safety-related issues addressed

in the Section 21(a) Report that related to the current MMS and USCG regulatory regime.

An underlying consideration for the application of BAST is the coupling of resource discovery and technological development. As a result of additional hydrocarbon discoveries, industry will be challenged to develop new technologies for the exploitation of these additional reserves in new areas.³³ The assumption made by the agencies regulating OCS activities is that, historically, the oil industry has been successful at developing appropriate technologies when given reasonable incentives. The OCS leasing process is one area that MMS provides such incentive, offering extended lease terms for deepwater tracts that may require the use of innovative technology.

Regulation is another area that MMS may provide incentive for technological development. Proposed changes to the rules applicable to OCS safety will be discussed in Chapter 3. The current rules, in the form of OCS Orders, are considered by MMS to be dynamic and may be revised as advances are made in knowledge of the operating environment and technology. However, the perception that it is incumbent upon the offshore industry to keep the regulating agencies apprised of such advances in order that timely revisions can be made to the OCS Orders, appears to have been ineffective. Many OCS Orders have not been revised in more than 10 years and some new requirements are proposed in response to recommendations made by accident investigation panels and others.³⁴

Workplace Safety Data Collection and Information Program

In addition to issues concerning the implementation of the BAST requirement, the Section 21(a) Report also addressed a recommenda-

tion that the collection of workplace safety data be improved. The National Research Council's Marine Board Commission on Engineering and Technical Systems established a Committee on Outer Continental Shelf Safety Information and Analysis in response to a request by MMS in June 1982. The resulting report, entitled, "Safety Information and Management on the Outer Continental Shelf," was published by the National Academy Press in 1984.³⁵ The following discussion of how OCS safety information management can be improved is based on several findings of the study.

MMS is at a disadvantage in its efforts to motivate industry to conduct safe operations and to obtain basic safety data because it limits its authority to the operator or lessee. Since much of the work on the OCS is conducted by contractors, MMS has no contact with these companies and must rely on the operator or lessee for information concerning the safety of their operations. MMS could choose administratively to request information necessary from all contractors but probably should target its efforts with those companies that are involved in operations having significant safety problems.

Federal regulatory influence over OCS safety is primarily manifested through the industry. Therefore, the government needs reliable casualty information so that the effectiveness of the procedures implemented to achieve the goals of the policies it sets can be determined. A useful safety information system needs to record data in a manner that reflects both the frequency of occurrence and the severity of events. The data also need to be in a form that is conducive to analysis. Monitoring safety performance -- the ability to document safety results and trends and to quantify the effects of

policies and regulations -- is central to fulfilling the Minerals Management Service's role in achieving OCS safety.³⁶

MMS already has implemented many of the components of a safety information system but the program has several missing elements. A fundamental weakness is that worker population data (such as histories of experience and training) for the entire OCS workplace are not collected. This means that the exposure data are not as complete as the event data, making analysis difficult. The International Association of Drilling Contractors (IADC) data, on the other hand, includes exposure information that allows frequency rates for lost time accidents to be calculated. This allows the accident rates to be normalized by a standard unit; in this instance, man hours of exposure. The potential value of this "normalized data" will be illustrated in Chapter 3. Comparable, OCS-specific frequency-rate statistics cannot be developed as readily from MMS or Coast Guard data because information on exposure, i.e., man hours on the OCS, is lacking.³⁷

There are two other major deficiencies with the MMS safety information and management system. The raw data is contained in the events file, established in 1970 by the Gulf of Mexico region. Since that time, OCS operations have taken place off the coasts of Alaska, California, and in the Atlantic but the geographic coverage of the historical data is complete only for the Gulf of Mexico. The second limitation of the system is the relatively primitive state of development of the data base. Other than simple sorting operations, by year or type of accident, for example, analysis can only be accomplished through special study.³⁸

MMS has established a computerized accident information management system at its national headquarters in Reston, Virginia. The program is still under development and should eventually solve the problems described above. However, the Gulf of Mexico is still the only OCS region that has a complete data file since 1970.

Notes

1. U.S., President, Proclamation, "Policy of the United States with Respect to the Natural Resources of the Subsoil and Sea Bed of the Continental Shelf," September 28, 1945; from the U.S. Department of the Interior/Minerals Management Service, OCS Laws Related to Mineral Resource Activities on the Outer Continental Shelf, OCS Report MMS 85-0069, Presidential Proclamation No. 2667.
2. Submerged Lands Act, U.S. Code, Title 43, Sections 1301 et seq.
3. Ibid.
4. Outer Continental Shelf Lands Act, U.S. Code, Title 43, Sections 1331 et seq.
5. U.S. Department of the Interior/Minerals Management Service, "Fact Sheet," MMS Gulf of Mexico OCS Region, Metairie, LA, 1984, p. 1.
6. Ibid. (This commission is commonly referred to as the "Linowes Commission.")
7. Ibid, p. 2.
8. U.S. Code of Federal Regulations, Title 30, Part 250.10, Jurisdiction, from U.S. Department of the Interior/U.S. Geological Survey/Bureau of Land Management, Compilation of Regulations Related to Mineral Resource Activities on the Outer Continental Shelf, Reston, VA, 1981, p. I-272.

9. Outer Continental Shelf Lands Act, U.S. Code, Title 43, Sections 1331 et seq.; National Environmental Policy Act of 1969, U.S. Code, Title 42, Sections 4321 et seq.; Coastal Zone Management Act of 1972, U.S. Code, Title 16, Sections 1451 et seq.; and the Outer Continental Shelf Lands Act Amendments of 1978, U.S. Code, Title 43, Sections 1801 et seq.
10. U.S. Code of Federal Regulations, Title 30, Part 250, Regulations. From the U.S. Department of the Interior, Compilation of OCS Regulations, pp. I-266 to I-307.
11. 30 CFR 250.2(o); Ibid, p. 268.
12. 30 CFR 250.2(q); Ibid.
13. National Research Council, Safety and Offshore Oil, p. 241.
14. 30 CFR 250.11(a)(2), p. I-272.
15. Minerals Management Service, Gulf of Mexico OCS Region, OCS Order No. 5, Section 1, 1980.
16. National Research Council, Safety Information and Management on the Outer Continental Shelf, p. 67.
17. Outer Continental Shelf Lands Act Amendments of 1978, Public Law 95-372 (92 STAT.654), now codified with slightly different language at 43 USC 1347(a).
18. The Section 21(a) Report was the result of a joint MMS and USCG analysis of "Safety and Offshore Oil" which had been submitted to the agencies, on their own request, in order to determine a basis from which to conduct their mandated study. From: Implementing Best Available and Safest Technologies for Offshore Oil and Gas, Report by the Panel on Best Available and Safest Technologies, Assembly of Engineering, National Research Council, by Leonard C.

- Meeker, Chairman (Washington, D.C., 1979), p. iii (see also Note 14 from Chapter 1).
19. Ibid.
 20. U.S. Department of the Interior/Minerals Management Service, "Oil and Gas and Sulphur Operations on the Outer Continental Shelf," Federal Register 51, No. 68, April 9, 1986, 12215.
 21. Ibid.
 22. Outer Continental Shelf Lands Act Amendments of 1978, Public Law 95-372 (92 STAT.654), now codified with slightly different language at 43 USC 1347(a).
 23. National Research Council, Implementing Best Available and Safest Technologies for Offshore Oil and Gas, p. 5 (includes reference to House Report #95-590 at 59).
 24. Ibid.
 25. Ibid.
 26. Outer Continental Shelf Lands Act Amendments of 1978, Public Law 95-372 (92 STAT.654), now codified with slightly different language at 43 USC 1347(a).
 27. Section 21(a) Report, "Joint Report by the U.S. Coast Guard and Minerals Management Service Pursuant to Requirements in the Outer Continental Shelf Lands Act Amendments of 1978," pp. v-vi.
 28. National Research Council, Implementing Best Available and Safest Technologies for Offshore Oil and Gas, p. 4 (includes reference to Senate Conference Report [S-95-1091] at 108).
 29. National Research Council, Safety and Offshore Oil.
 30. Section 21(a) Report, "Joint Report by the U.S. Coast Guard and Minerals Management Service Pursuant to Requirements in the Outer

Continental Shelf Lands Act Amendments of 1978," p. iv. Reference to the Federal Register included as 46 FR 32885.

31. Ibid.

32. Ibid, p. v.

33. Ibid, p. 2.

34. Minerals Management Service, "Oil and Gas Operations on the OCS," Federal Register 51, No. 52, March 18, 1986, 9316.

35. National Research Council, Safety Information and Management on the Outer Continental Shelf.

36. Ibid, p. 3.

37. Ibid, p. 16.

38. Ibid, p. 27.

Chapter 3

PRESENTATION AND ANALYSIS OF THE SAFETY DATA

Introduction

Three data sets have been collected for the period 1975-1985. The International Association of Drilling Contractors (IADC) information has been gathered from annual Accident Statistics Task Group reports obtained from the IADC Accident Prevention Subcommittee in Houston, Texas. The United States Coast Guard (USCG) Office of Merchant Marine Safety in Washington, DC, provided annual summaries of casualties that have been included in their Marine Safety Information System. The Minerals Management Service (MMS), Offshore Rules and Operations Division, located in Reston, Virginia, was used as a source for safety data that has been stored in their OCS Events File.

IADC Data

The IADC Accident Prevention Subcommittee tabulates worldwide annual safety information from participating member companies. It is the only set of information that includes man hours of exposure (MHE), which enable the data to be normalized. MHE is defined as the total number of hours that those personnel working on drilling operations are subject to occupational hazards and thereby exposed to risk. For example, a roughneck typically works 12 hours, then has 12 hours off. Therefore, in each 24-hour period, the roughneck on a drilling location contributes 12 MHE to the total of the operation. While the number of people working on an offshore rig varies daily, a MHE count of 1,000 would not be unusual for a 24-hour period. Injuries and fatalities resulting from the catastrophic failure of offshore facilities clearly

skews the results of an MHE normalized data base. However, the use of MHE as a measure of the average level of intensity that the industry is performing at over the course of a given year allows comparisons to be made between years.

The annual tabulations received from the IADC have been grouped according to the type of drilling category. The categories selected were for drilling contractors that operated domestically on land as well as in state and federal waters. To collect the data the IADC uses the drilling contractors' accident reports that are sent in each month as part of a voluntary safety program. The original source of the information is the hourly log or "Charlie Report" filled out by the drillers during each tour or shift.

The IADC data set includes land-based accident information to allow comparisons to be drawn between the entire domestic drilling industry. The products of this effort is Table 1, which shows yearly frequencies for lost time accidents (LTA) during the period 1975-1985. The IADC definition of LTA is an injury that causes an employee to miss at least 12 hours of work. Frequency rate is the number of LTA occurring in 1,000,000 MHE, while incidence rate expresses the occurrence of LTA per 200,000 MHE. The IADC used the term frequency rate exclusively until 1982 when incidence rates were also calculated and appeared in their annual summaries. Incidence rates may be obtained by simply dividing the frequency rates by five. The use of incidence rates allows the more subtle differences in the data to be graphically highlighted on scales having a far smaller range. However, because the incidence rate numbers are five times lower than the frequency rates,

TABLE 1
LOST TIME ACCIDENTS OF 12 HOURS OR GREATER EXPRESSED
AS FREQUENCY RATES (PER 1 MILLION MAN HOURS)

YEAR	U.S. LAND	U.S. OFFSHORE	U.S. COMBINED LAND AND OFFSHORE
1975	59.13	41.85	51.63
1976	56.17	59.17	57.17
1977	59.80	46.57	54.38
1978	63.65	49.68	58.08
1979	58.08	45.66	53.12
1980	57.76	40.94	52.19
1981	49.35	34.06	44.16
1982	40.32	26.44	34.90
1983	50.32	20.99	36.56
1984	60.62	24.95	44.69
1985	51.96	18.54	36.57

SOURCE: International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986. The offshore data includes State Waters and Federal Outer Continental Shelf areas.

NOTE: Accident rates for offshore areas generally declined over the period 1975-1985.

the IADC may be attempting to minimize the importance of the results through the use of statistical manipulation.

The IADC data have several significant limitations. For example, only injuries that occurred to drilling contractor (and sub-contractor) personnel are included in this data set. Also, the offshore information includes incidents that occurred in both state and federal waters. Although these data are the most complete available, they represent only a percentage of reporting from member contractors who participated in a voluntary program. Reporting percentages ranged from a low of 69 percent of contractors in 1980 to a high of 100 percent in 1984.¹ Because more than two-thirds of the member companies reported every year, the data are assumed to be a representative survey of the entire population and therefore statistically valid. It is possible, however, that the poorest safety performers were not sampled, which could skew the results. Similar data sets, such as the OSHA safety information discussed in Chapter 1, are not available in an offshore-specific format, which would allow for a comparison of the two safety records during the study period.

The codes of the IADC member companies participating in the program vary from year to year. This is unfortunate because it precludes the analysis of a small, but consistent sample of contractors throughout the 10-year period that could have provided a valuable control group. Comparisons drawn between the small sample and the entire population of participating member companies would have given additional credibility to the use of the IADC data base.

The reporting of IADC fatalities was not itemized for offshore events during the years 1975 through 1979. The fatality totals for

those years are aggregates of domestic land and offshore occurrences as well as foreign events, and therefore have not been included in the presentation of the three data sets. The IADC offshore fatality information is presented in Table 2.

USCG Data

The USCG data represents only a partial, voluntary reporting of events to the Marine Safety Office that have been included in the Coast Guard's Marine Safety Information System. An operator or drilling contractor was not required to report LTA to the Coast Guard until 1982. Prior to that date, some of the events that were reported by industry did not fit into specific categories and were never entered in the safety information data base. The 1982 requirement represents the lag time between the 1978 Outer Continental Shelf Lands Act Amendments and the promulgation of the more detailed accident reporting regulations mandated by the Act. The totals of reported LTA and fatalities for the years 1975 through 1979 are, according to the Commandant of the Marine Safety Office, admittedly low and probably do not accurately portray the safety situation that existed during that period.² In 1980 the USCG changed their data file format by expanding the various categories of accident type. The new format enabled the information to be computerized, which allowed more of the reported data to be used for analysis. The net result was an increase in the number of LTA from that year forward. The USCG data presented here was obtained by mail and telephone and has been presented in the same format as received from the Marine Safety Office.

LTA criterion for USCG data is a 72-hour incapacitation, which may partly account for the smaller numbers than found in the IADC data.

TABLE 2

OFFSHORE FATALITIES, MAN HOURS OF EXPOSURE, AND FATALITY
OCCURRENCE RATIO PER MILLION MAN HOURS OF EXPOSURE

YEAR	FATALITIES	MAN HOURS OF EXPOSURE (Millions)	FATALITIES MAN HOURS OF EXPOSURE (Millions)
1980	10	37.077	0.27
1981	8	43.599	0.18
1982	8	46.558	0.17
1983	5	43.456	0.11
1984	10	51.220	0.19
1985	37	47.896	0.77

SOURCE OF FATALITY AND EXPOSURE DATA: International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986. The data includes State Waters and Federal Outer Continental Shelf areas.

NOTE: Prior to 1980, IADC fatality data was not offshore-specific. In 1984 the fatality occurrence ratio was 0.19 fatalities per million man hours of exposure. In 1985 the ratio increased to 0.77 while the exposure declined by more than 3.3 million man hours. Possible causes of this increase in fatalities are discussed in the analysis section of this chapter.

However, a conclusive determination of this is not possible because of the voluntary nature of the IADC reporting system and the fact that reporting was not mandatory to the USCG until 1982. There is also no USCG-generated worker population data that enables the accident data to be normalized. Therefore, the Coast Guard information will be presented together with the MMS data. In addition, the offshore data includes both state and federal waters and the reported events include diverse transportation and vessel operation activities.

MMS Data

MMS requires accident reporting under the authority of 30 CFR 250.45 and 33 CFR 153.203. The objective of these regulations is to provide the necessary information for taking corrective and preventive actions that reduce or eliminate the likelihood of recurrence. The term "accident" includes oil spills as well as fires, personal injuries and death, structural failures, and other malfunctions. OCS Order No. 7, Section 2.3, stipulates that the lessee is required to file an accident report within 10 days of the date of occurrence. All lost time accidents of 72 hours or greater are to be reported. The lessee must immediately notify the district supervisor of all serious accidents, any death or serious injury, and all fires. Discharges in violation of regulations are to be reported immediately. Corrective or preventive actions may include the issuance of a notice to lessee, well shut-in, investigation, or revision to regulations.

MMS data are concerned with events that occurred on the Outer Continental Shelf (OCS) involving drilling, production, and workover activities. The MMS data was compiled from a specially requested run of the events file obtained from the Offshore Rules and Operations

Division in Reston, Virginia. No population information exists within the data set. However, several sources of OCS statistics could potentially be used to normalize the data. These include the annual number of boreholes drilled, production figures, and the number of well starts in a given year. Although not as appropriate an indicator as the IADC man hour data, the well starts information appears to provide the most reliable comparison of the level of OCS drilling activity that is available from a federal agency. Table 3 presents the relationship between OCS well starts and MHE for the study period. With the exception of a decrease from 1975 to 1976, the annual trend has been a consistent increase in the average number of MHE per well start. This seems to indicate that it took longer to drill wells, or was a decrease in the efficiency of OCS drilling operations from 1976 to 1985.

One variable that is not taken into account in this analysis is average well depth, which can generally be assumed to have increased during the study period. Over time, the better drilling prospects are typically found further offshore in deeper water or simply in deeper, unexplored formations. However, specific well depth data for several OCS planning areas do not illustrate this trend and are shown in Table 4. Despite the influence that well depth probably has on these data, it is possible that OCS safety regulations implemented during the study period have contributed to the increase in the per well MHE and therefore to the relationship between operational efficiency and accident rates. Testing, required inspections, and other time-consuming operations all add to the total MHE during a given drilling project. Acknowledging these limitations, the well starts and MHE data will be

TABLE 3
WELL STARTS AND MAN HOURS OF EXPOSURE

YEAR	WELL STARTS ^(a)	MAN HOURS OF EXPOSURE ^(b)	AVERAGE MAN HOURS OF EXPOSURE PER WELL START ^(c)
1975	841	18,663,520	22,192
1976	1,086	18,184,585	16,745
1977	1,220	28,834,239	23,635
1978	1,139	36,173,267	31,759
1979	1,109	36,043,946	32,501
1980	1,079	37,077,474	34,363
1981	1,109	43,599,536	39,314
1982	1,159	46,558,981	40,172
1983	1,066	43,456,679	40,766
1984	1,136	51,220,414	45,088
1985	1,040	47,896,128	46,054

SOURCES:

(a) Minerals Management Service, Federal Offshore Statistics: 1985 (Washington, D.C.: 1987, OCS Report 87-0008), p. 72, TABLE 65. Includes Federal Outer Continental Shelf areas only.

(b) International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986. Includes State Waters and Federal Outer Continental Shelf areas.

(c) Calculated from (a) and (b) to illustrate trend.

NOTE: With the exception of 1976, there has been an increase in exposure per well start every year. The possible causes of this trend are discussed in the analysis section of this chapter.

TABLE 4
AVERAGE WELL DEPTHS IN TWO OUTER CONTINENTAL SHELF REGIONS

YEAR	ALASKA ^(a)		EASTERN GULF OF MEXICO ^(b)	
	TOTAL WELLS	AVERAGE DEPTH IN FEET	TOTAL WELLS	AVERAGE DEPTH IN FEET
1975	1	5,150	10	13,739
1976	4	5,924	--	-----
1977	9	13,508	3	14,905
1978	3	14,153	--	-----
1979	3	10,175	--	-----
1980	5	11,453	1	20,450
1981	--	-----	8	12,477
1982	4	13,286	1	21,068
1983	4	14,367	--	-----
1984	11	8,293	--	-----
1985	21	9,750	7	17,377

SOURCES:

(a) Minerals Management Service, Alaska Summary Report/Index: January 1986 - December 1986 (Washington, D.C.: 1987, OCS Information Report MMS 87-0016), p. 26, TABLE 10.

(b) Minerals Management Service, Gulf of Mexico Summary Report/Index: November 1984 - June 1986 (Washington, D.C.: 1986, OCS Information Report MMS 86-0084), p. 28, TABLE 11.

NOTE: Possible relationships between well depth and safety are discussed in the analysis section of this chapter.

TABLE 5
ACCIDENTS AND FATALITIES AS REPORTED TO THE UNITED STATES
COAST GUARD AND THE MINERALS MANAGEMENT SERVICE

YEAR	UNITED STATES COAST GUARD ^(a)		MINERALS MANAGEMENT SERVICE ^(b)	
	LOST TIME ACCIDENTS	FATALITIES	LOST TIME ACCIDENTS	FATALITIES
1975	26	12	15	11
1976	40	20	18	12
1977	30	9	26	12
1978	27	3	28	17
1979	16	15	20	14
1980	119	17	24	15
1981	264	13	38	12
1982	677	22	363	18
1983	740	26	317	8
1984	1,057	25	286	14
1985	913	20	334	15

SOURCES:

(a) Telephone interview with Lt. Commander Moniz, United States Coast Guard, Office of Merchant Marine Safety, Washington, D.C., August 1986.

(b) Interview with Ulysses Cotton, Minerals Management Service, Offshore Rules and Operations Division, Reston, VA, September 1986.

NOTE: The increase in the 1980 Coast Guard lost time accident data reflects a change in reporting format discussed on page 3-6. Beginning in 1982, both the Coast Guard and the Minerals Management Service required that accidents be reported by offshore owners, operators, and persons in charge of Outer Continental Shelf Facilities. Prior to 1982, the reporting of lost time accidents was voluntary. The Section 21(a) Report (discussed in Chapter 2) recommended the mandatory reporting, which was implemented under the regulatory authority pursuant to the 1978 Outer Continental Shelf Lands Act Amendments.

used to normalize both the MMS and USCG data in the analysis section. The MMS and USCG accident and fatality data are shown in Table 5.

Similar to the USCG, MMS considers an LTA to be a 72-hour lost time event to an individual that gets reported and entered in the Events File. However, because the MMS Events File contains data on production and workover activities as well as drilling operations, the normalization of the accident data is more complex than would first appear. Also, events may get counted twice because an injury or fatality is considered to be an event, when it is actually the effect of an event such as a fall, blowout, fire, or explosion. MMS recognizes that such "double counting" is an area of weakness in this safety reporting and data collection system, but does not appear to have any solutions at this time. Partial reporting and incomplete entry into the data base is also a problem that plagues the successful use of the events file for historical analysis, although it was not intended for that purpose.³

Despite its limitations, the Events File is an integral component of the MMS Safety Information Program. Data collected through this program is made available in annual reports to Congress, pursuant to 43 USC 1343. The reports include the number of violations of safety regulations reported or alleged, investigations undertaken, as well as the results and any administrative or judicial action taken subsequent to the investigation. A reported LTA or fatality is often, but not necessarily, the result of a safety violation. Since the report to Congress involves regulatory violations, the primary purpose of the Events File is to help the agency comply with the law. If properly managed in the future, the data base should ultimately provide infor-

mation useful for historical analysis. Data from the Events File have been used during this research because they are the most accurate source available from MMS.

Analysis

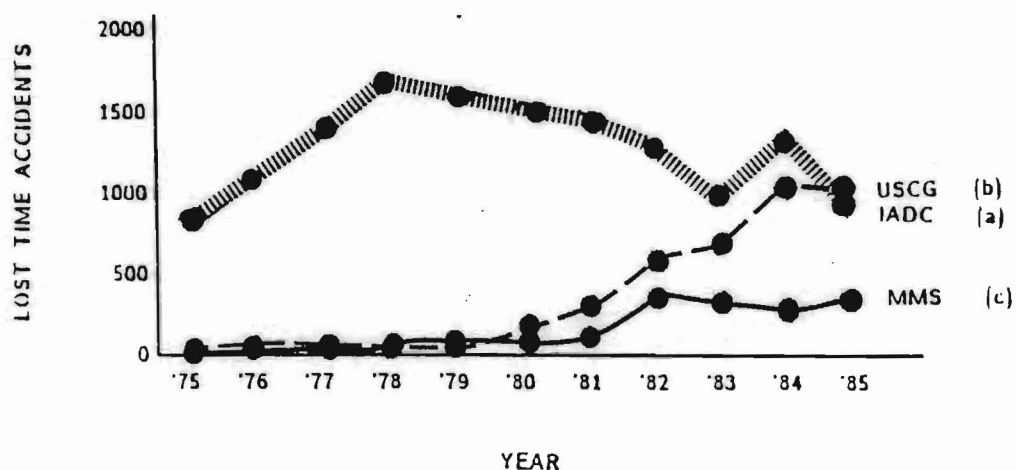
Trends common to the three sets of LTA data are shown in Figure 1. Annual totals for both MHE and well starts are graphed on separate scales in Figure 2. The dramatic increase in LTA beginning in 1980 for the USCG and in 1982 for MMS can be primarily attributed to changes in the accident reporting systems of both agencies. As previously mentioned, in 1980 the Coast Guard initiated changes in the manner that accident data was recorded. These changes allowed the information to be computerized and was, therefore, more readily accessible for safety analyses.

The average number of MHE per OCS well start is shown in Figure 3. Reasons for the increasing trend of MHE per well start will be discussed later in this chapter.

The 1980 MOU between the USCG and MMS defined the particular areas of interest in which the agencies should concentrate their data collection efforts.⁴ This allowed the causal information to be correlated with specific accident events. Past practice had been to determine only the possible causes, which had the effect of considering each accident as a discrete experience. The refinement in causal data categories recognized that accidents often do not have a single cause. A chain of events, each having a specific cause, typically develops into an accident. The recognition that various types of accidents are frequently caused by a certain chain of events was a fundamental step in attempting to increase safety through regulatory control.

FIGURE 1

LOST TIME ACCIDENTS AS REPORTED BY THREE DATA SYSTEMS



SOURCES:

(a) International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986.

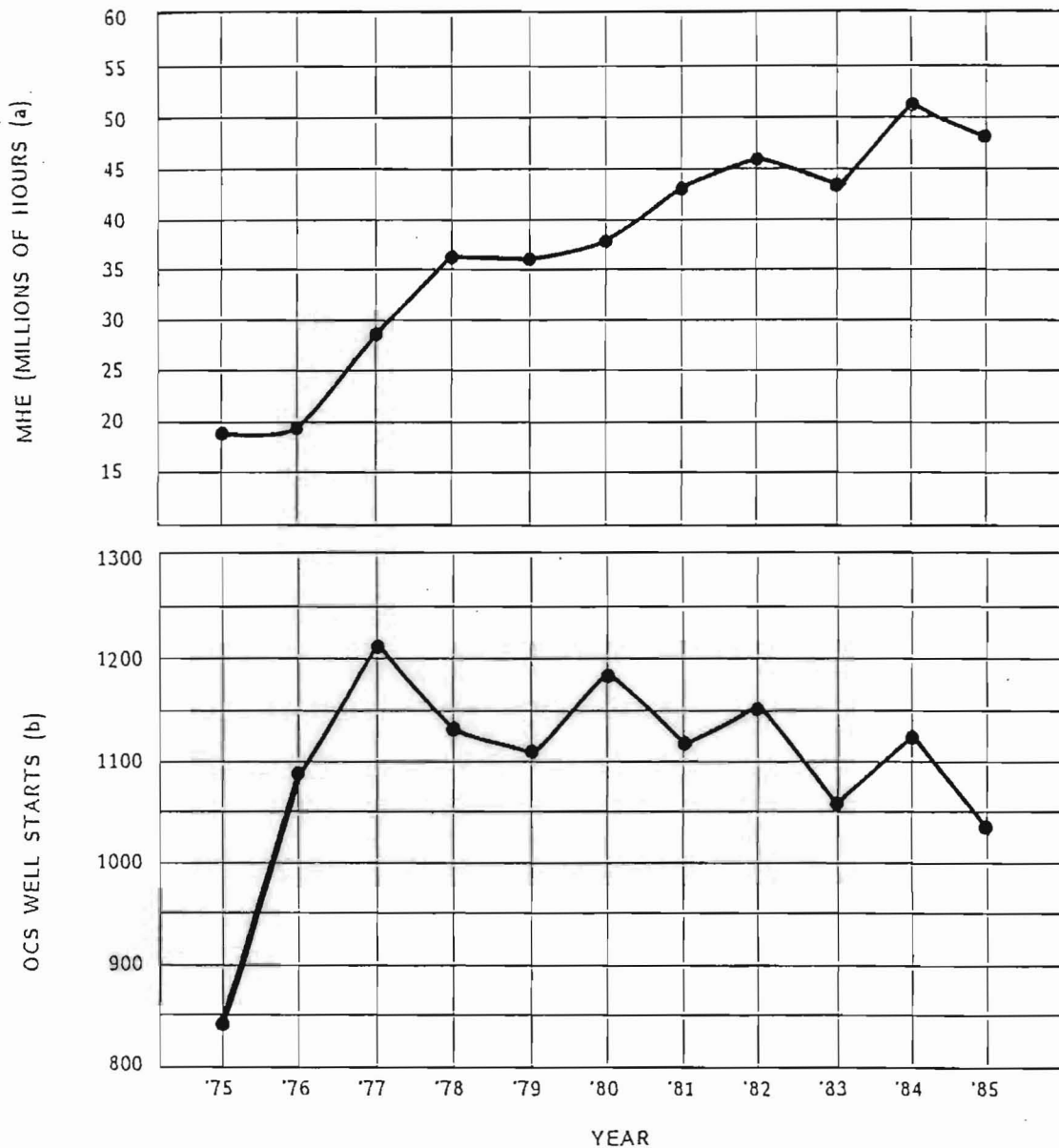
(b) Telephone Interview with Lt. Commander Moniz, United States Coast Guard, Office of Merchant Marine Safety, Washington, D.C., August 1986.

(c) Interview with Ulysses Cotton, Minerals Management Service, Offshore Rules and Operations Division, Reston, VA, September 1986.

NOTE: Discrepancies arise because the International Association of Drilling Contractors uses 12 hours to define a reportable accident for State Waters and Federal Offshore areas while the agencies use 72 hours to define a reportable accident. However, the Minerals Management Service data includes only Federal Outer Continental Shelf events whereas the Coast Guard data includes both offshore areas. A possible cause of the apparent increase in accidents reported to the Federal agencies between 1980 and 1982 may be the implementation of revised reporting requirements discussed in this Chapter.

FIGURE 2

WELL STARTS AND MAN HOURS OF EXPOSURE BY YEAR



SOURCES:

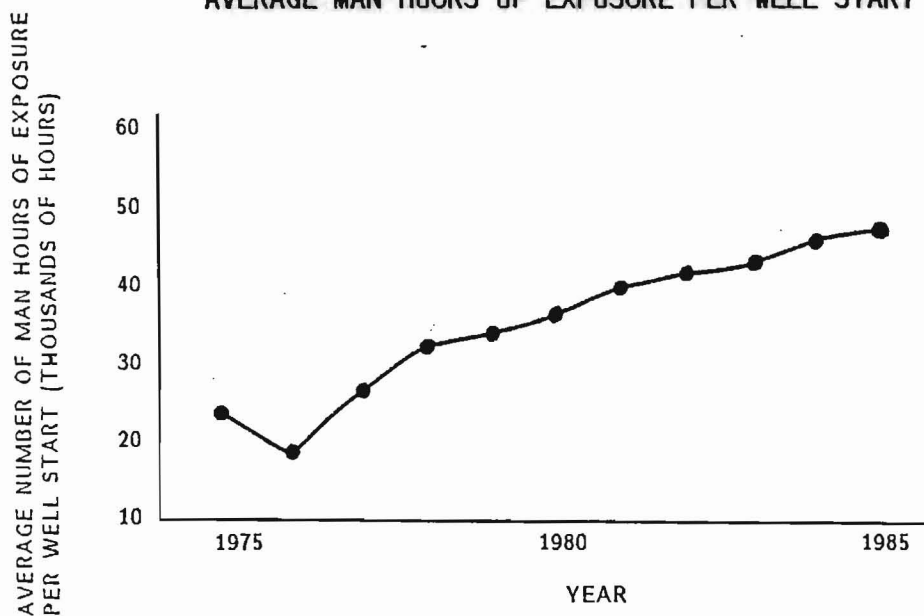
(a) International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986. Includes State Waters and Federal Outer Continental Shelf areas.

(b) Minerals Management Service, Federal Offshore Statistics: 1985 (Washington, D.C.: 1987, OCS Report 87-0008), p. 72, TABLE 65. Includes Federal Outer Continental Shelf areas only.

NOTE: Since 1980, the general fit between these curves lends credibility to the methodology of using well starts and man hours of exposure to normalize the data. Reasons for the increase in exposure time on a per well basis are discussed in the analysis section of this chapter.

FIGURE 3

AVERAGE MAN HOURS OF EXPOSURE PER WELL START



SOURCES: International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986; and Minerals Management Service, Federal Offshore Statistics: 1985, (Washington, D.C.: 1987, OCS Report 87-0008), p. 72, TABLE 65.

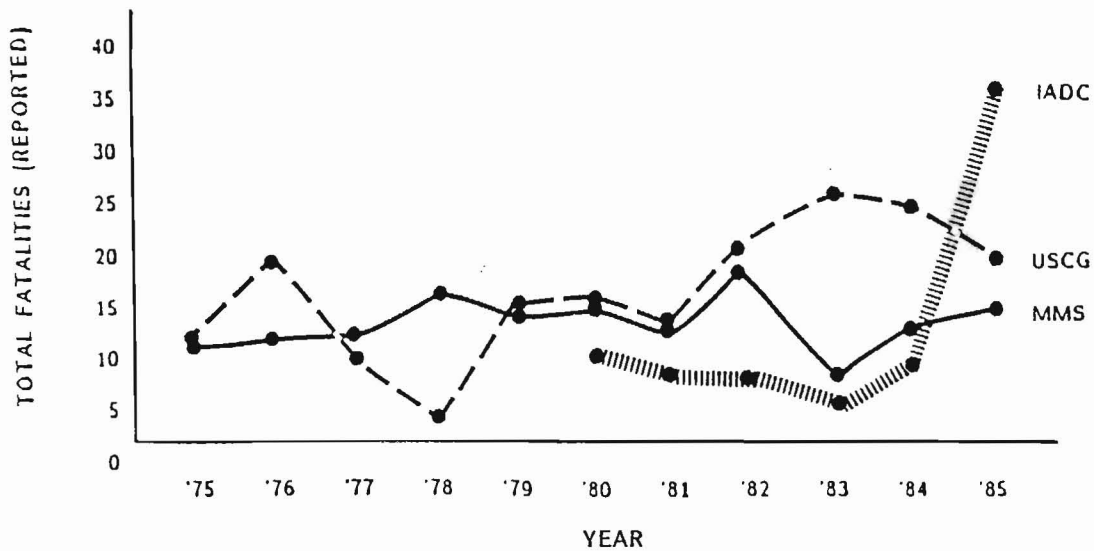
NOTE: Except for 1976, the yearly trend has been an increase in exposure on a per well basis.

The information sought in personnel accidents and injury reports was further strengthened on August 16, 1982, when the Coast Guard published an interim rule revising casualty reporting requirements of Title 33, CFR Part 146, and various parts within Title 46, CFR. The rule incorporated a revised Coast Guard form, Report of Marine Accident, Injury, or Death (CG-2692).⁵ The level of detail for personnel accident information collected on this form was substantially improved from the previous collection form (CG-924E).⁶

Other evidence supporting the conclusion that the low numbers of LTA reported to the USCG and MMS prior to 1980 were caused by changes in format is found in the fatality data. These numbers are far more consistent throughout the three sets of data during the 1980-1985 period (Figure 4). This is particularly true of the IADC and MMS data sets. The shapes of the fatality curves are similar, with a low occurring in 1983 followed by a rapid increase. The discrepancy between the MMS and USCG data in 1978 is unexplainable but lends support to the idea that the quality of information has improved since 1980. The computerized reporting systems now in place probably contributes to the results being more unified.

Beginning in 1980, the USCG fatality curve is almost a mirror image of the MMS and IADC curves. This is not surprising because both data sets should be subsets of the USCG fatality totals. The information that is reported to the Coast Guard includes events that occur during operations that would not be reported to either MMS or IADC. The problem is that the absolute number of fatalities reported to the IADC in 1985 is considerably higher than the USCG number for that year. However, the total number of LTA reported to the USCG in 1985 (Figure

FIGURE 4
FATALITIES REPORTED BY THREE DATA SYSTEMS*



SOURCES:

(a) International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986.

(b) Telephone Interview with Lt. Commander Moniz, United States Coast Guard, Office of Merchant Marine Safety, Washington, D.C., August 1986.

(c) Interview with Ulysses Cotton, Minerals Management Service, Offshore Rules and Operations Division, Reston, VA, September 1986.

NOTE: The numbers of fatalities reported to the Coast Guard for 1977 and 1978 are lower than those reported to the Minerals Management Service. Possible reasons for this disparity are explored in the analysis section of this chapter.

* The International Association of Drilling Contractors did not tabulate offshore-specific fatality data until 1980.

1) is higher than the IADC total. This is particularly disturbing when considering that the IADC LTA criteria is a 12-hour injury whereas both the USCG and MMS use 72 hours of incapacitation to determine the minimum LTA. The apparent anomaly can perhaps be explained by the number of non-IADC member personnel injured that the USCG includes in their overall marine safety data. For example, the 1985 USCG data includes 58 LTA entries for offshore service vessels. If a relatively large number of those injuries occurred to personnel not counted by the IADC (anyone who does not work for the drilling company or its subcontractors), they would not have been included in the data.

The previously discussed changes in the USCG data collection and reporting format may also be partly responsible or perhaps some of the LTA were not counted due to gaps in the cooperative reporting system between USCG and MMS. In any event the IADC data seems to be the most consistent and reliable because their reporting format has not changed substantially during the period of record.

If the assumption is made that the IADC data is the most reliable, it allows for further analysis of the LTA trend. The IADC reported offshore data reveals an increase of 3.46 LTA per 200,000 MHE from 1975 to 1976. This was a nearly 30 percent higher frequency of LTA incidence over the previous year, and it occurred while the annual MHE decreased by more than 2.5 percent. An increase of 0.63 LTA per 200,000 MHE occurred between 1977 to 1978. This was a 6.4 percent higher frequency of LTA incidence in 1978, while the annual MHE increased by slightly more than 2 percent. A gradual decline in reported LTA incidence occurred between 1978 and 1983. This improved trend was followed by an increase of 0.79 LTA per 200,000 MHE from 1983

to 1984, which was a 16 percent increase over the previous year. The increase occurred while the annual MHE rose by more than 15 percent.

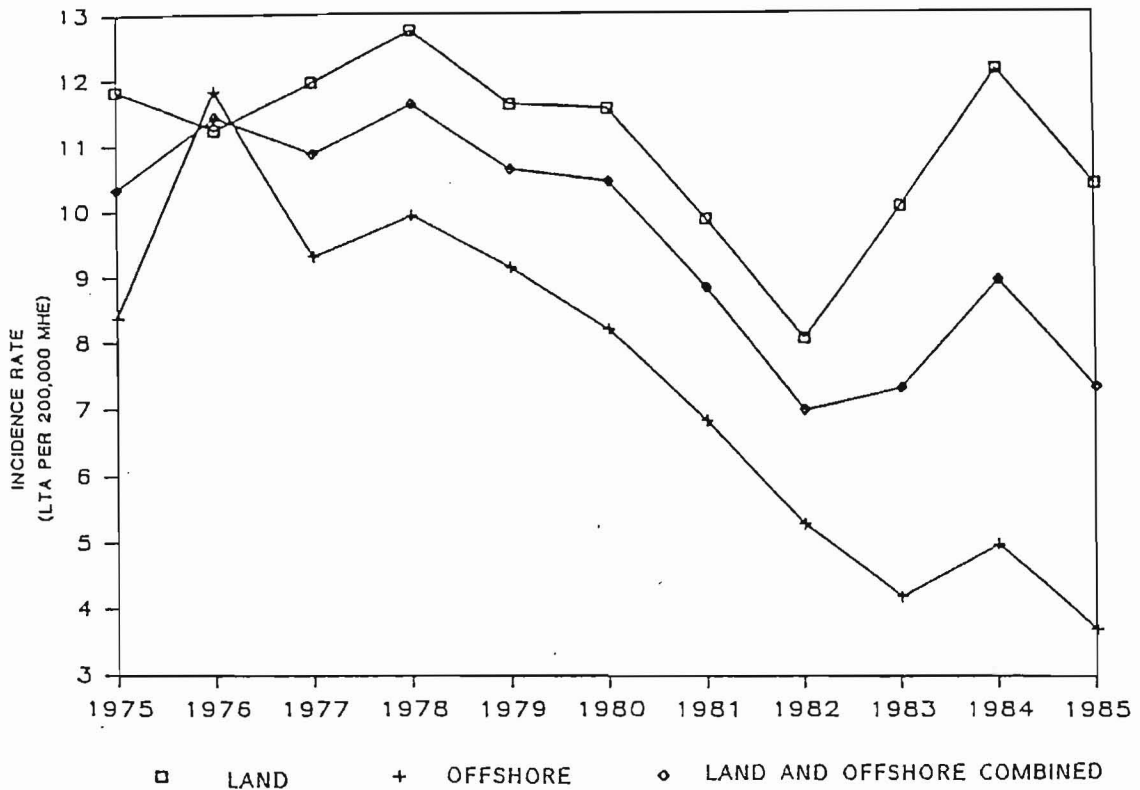
It should be noted that in 1976 the incidence rate for offshore areas was higher than for land (see Figure 5). In all other years the rates for water pulled down the rates for land but in 1976 this was not the case. A possible cause of this anomaly may have been the increase in offshore activity caused by the jump in the number of tracts leased during 1974 and 1975. In 1973 a total of 187 tracts were leased on the OCS, while the totals for 1974 and 1975 were 356 and 321, respectively.⁷ Industry was clearly in a "gearing up" phase in 1976, so that workers may not have had the necessary experience to conduct adequately safe offshore operations.

The 16-percent increase of LTA in 1984 can be partly explained by the expanded offshore activity, which peaked in that year with 51,220,414 MHE. It is possible that the age of equipment and poor maintenance practices also played a role in the increased LTA incidence rate. However, if the level of activity is considered to be the primary variable the reversal of the trend the following year could then be explained by increased contractor competition during 1985 as MHE declined by more than 3.3 million. If the situation described above is valid, it points out a possible deficiency in the normalization of the data by million MHE.

A similar argument can be made when considering the IADC fatality data. Figure 6 shows the number of fatalities per million MHE that occurred between 1980 and 1985. As noted above, the 1984 total MHE was 3.3 million greater than in 1985. However, the number of fatalities per million MHE increased from 0.18 to 0.77. This method of

FIGURE 5

INTERNATIONAL ASSOCIATION OF DRILLING CONTRACTORS ACCIDENT
INCIDENCE RATES FOR LAND, OFFSHORE, AND BOTH AREAS COMBINED

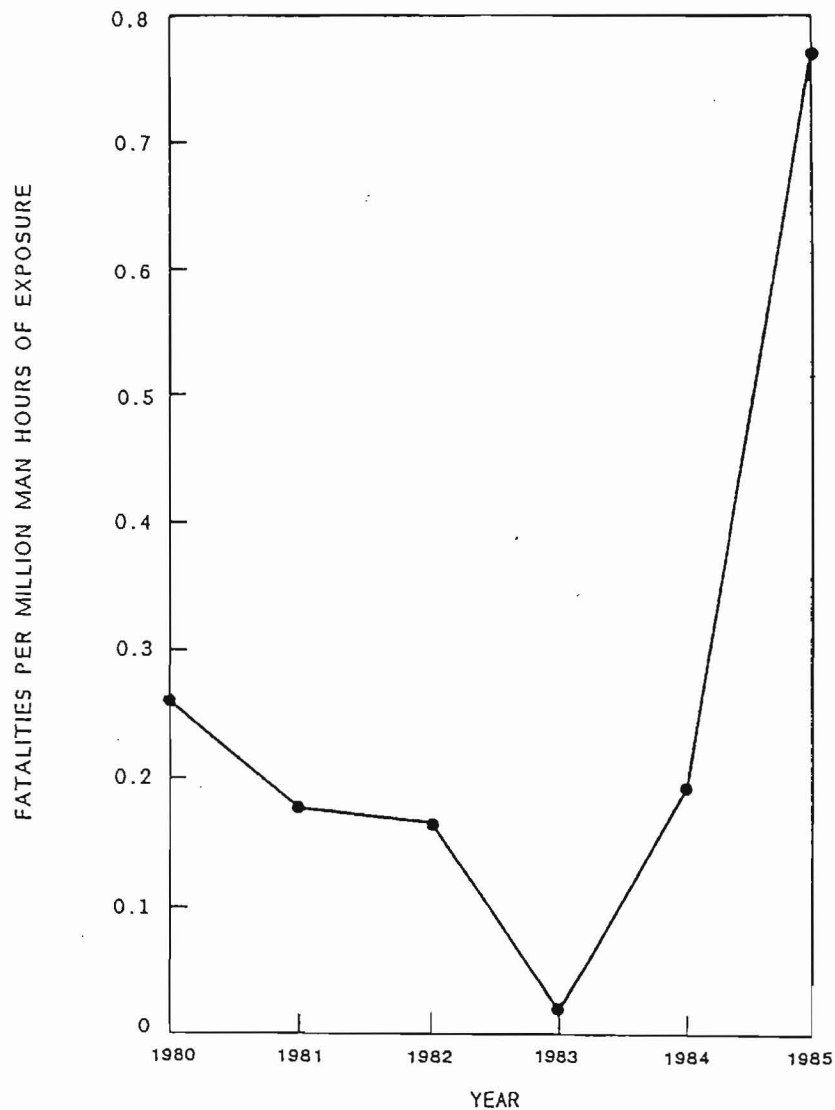


SOURCE OF BASIC DATA: International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986.

NOTE: The three categories are included to allow for comparisons of the entire domestic industry. After peaking in 1976, which is discussed in the text, the offshore data show a generally declining trend. However, while the yearly trend for land and offshore has been similar, there has been a net decrease in offshore incidence rate over the study period. A discussion of whether the reduction in offshore accident incidence rate may be significant is found in Chapter 4.

FIGURE 6

INTERNATIONAL ASSOCIATION OF DRILLING CONTRACTORS OFFSHORE
FATALITY RATES PER MILLION MAN HOURS OF EXPOSURE



SOURCE: International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986.

NOTE: The data include events that occurred in State Waters and on the Federal Outer Continental Shelf. One possible cause of the dramatic increase from 1984 to 1985 is, among other factors, the diminished availability of experienced workers, as discussed in the analysis section of this chapter.

normalization assumes that an unlimited supply of equally competent workers are available regardless of the demand. It is probable, however, that less experienced help is available for offshore employment as the total MHE increases. It appears that the quality of the offshore worker should not be considered a constant. Improved workforce training is a logical method of eventually reducing this problem, but it does not alleviate the short-term situation caused by inexperience.

Since the reporting of LTA to Federal agencies was not mandatory until 1982, the MMS and USCG data provide reasonably similar detail only from that date forward. Therefore, one possible conclusion is that a truly meaningful safety trend can only be established commencing in 1982. If it took at least until 1982 for the mandates of the 1978 OCS Lands Act to be effectively translated into the regulations contained in 46 CFR 109.411-413, 33 CFR 146, and 30 CFR 250.45, it follows that, while the event reporting crucial to safety analyses has been extremely variable in the past, it is more significant that they are similar from 1982 onward. However, this raises the possibility that the first hypothesis cannot be proven and that the need for a better data reporting system and an ongoing safety analysis are apparent.

The Section 21(a) Report, discussed in Chapter 2, included a recommendation from the 1981 study, "Safety and Offshore Oil," that the USCG and MMS coordinate and strengthen the collection of workplace safety data. It specifically suggested that "a single accident reporting form collected by a single agency could provide the kind of information needed to gain better understanding of the causal factors and characteristics of workers that could lead to improved safety."⁸

The USCG and MMS have agreed that coordination of their reporting systems would help to minimize duplication of efforts and point out areas of deficiency in safety data collection. The agencies had previously felt that the recommendation for the creation of a single accident reporting form would be unworkable because of differences in their responsibilities. However, the 18 March 1986 Federal Register contained a proposed MMS rule change under 30 CFR 250 that would eliminate the requirements for written accident reports.⁹ To comply with the requirements of the OCS Lands Act, as Amended, MMS would obtain copies of accident reports from the USCG in instances where reporting is required by Coast Guard rules. It appears that the Amendments left enough latitude to allow MMS to do this.¹⁰ One possible benefit of this procedure is that both agencies would be using the same raw data. The risk inherent with this type of system is that chances are increased that the information reported will either be incomplete or inaccurate.

To safeguard against such an occurrence, the Coast Guard is considering promulgating additional regulations that would require OCS leaseholders to submit copies of a log of work related fatalities, illnesses, and injuries requiring medical treatment other than first aid. The Occupational Safety and Health Administration (OSHA) requires that leaseholders tabulate and post such a log at the workplace. Although OSHA does not differentiate between land-based and offshore drilling, there are two items on this log that would be of benefit to the OCS data collection effort if the offshore information could be isolated. First, a lost time accident is considered a period of 24 hours or more. This is still twice the length of the IADC defined LTA.

Since the present USCG and MMS OCS accident data collection systems consider a 72-hour incapacitation a lost time accident, the inclusion of the 24-hour LTA data would be a great improvement. The second item records the severity of the accidents by noting the number of days lost in each case. The log is already being generated for OSHA, so if the Coast Guard required that the OCS-specific information be submitted it would not impose an additional data gathering burden on the employer.¹¹

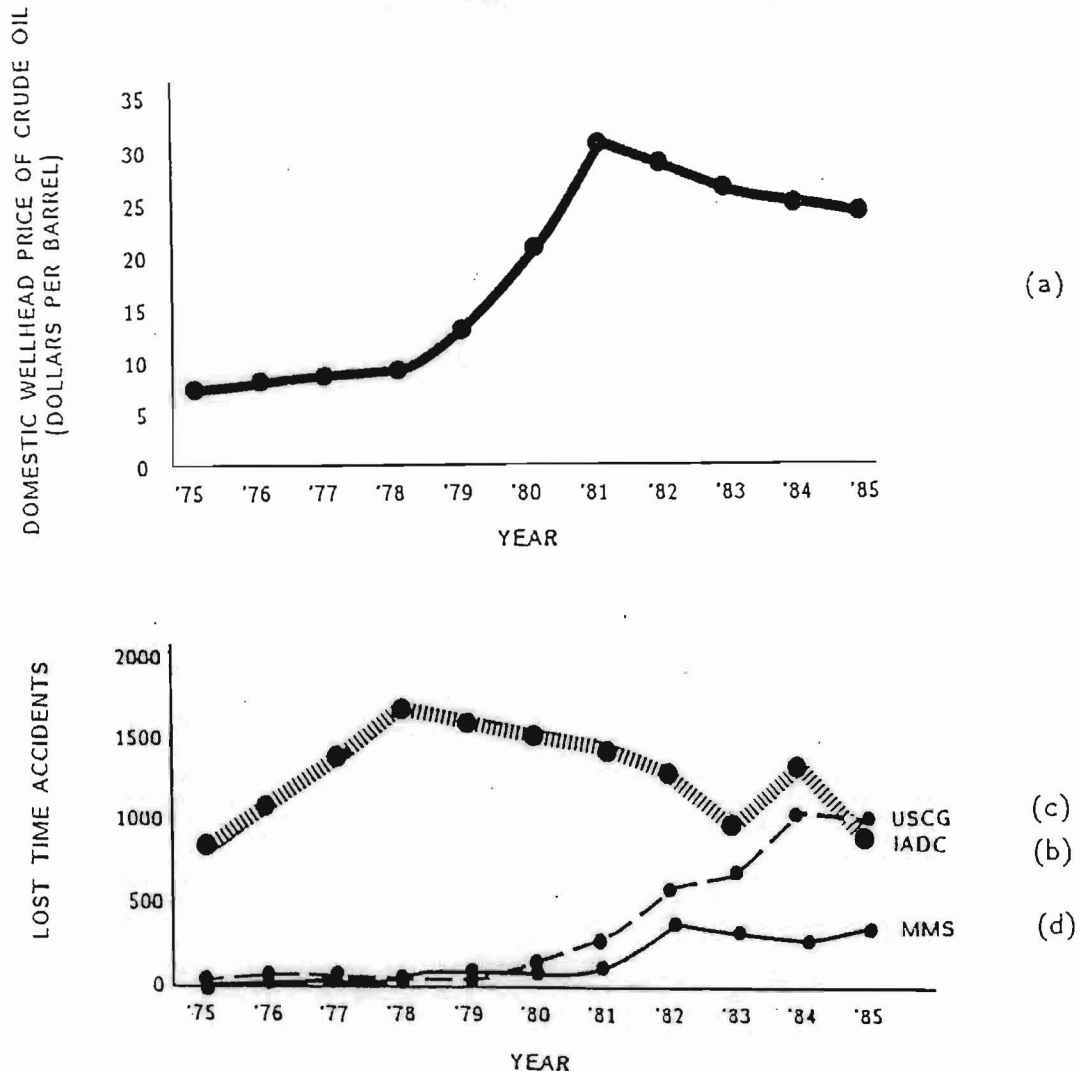
It appears that the Coast Guard will emerge as the lead agency for collecting OCS casualty data. However, the implementation of a successful accident reporting and analysis system for OCS accidents is not imminent.¹² There is still a considerable amount of work that needs to be done in several areas to improve the quality and accuracy of the data being reported.

The relationship between OCS safety trends and the price of crude oil are shown in Figures 7 and 8. Figure 7 illustrates several things, one being that there are major differences in the numbers of LTA reported by the various groups. In both figures, the oil price curves show that there is a poor correlation between the LTA data and the price of oil.

The dramatic increase in the price of oil between 1979 and 1981 does correspond to similar jumps in LTA reported by MMS and USCG. However, as previously discussed, those increases in LTA are primarily due to changes in reporting formats and requirements. During the oil price decline from 1981 to 1985 the IADC curve shows a general decline in LTA with a notable exception occurring in 1984. The MMS data indicates a decrease in LTA from 1982 to 1984 but an increase in 1985. The USCG LTA data shows an increase until 1984, then decreases in 1985.

FIGURE 7

A COMPARISON OF OFFSHORE LOST TIME ACCIDENTS
AND THE PRICE OF CRUDE OIL



SOURCES:

(a) Telephone Interview with the United States Department of Energy, Energy Information Administration, Washington, D.C., July 1987; and United States Department of Energy, Energy Facts, 1986 (Energy Information Administration, Washington, D.C.: DOE/EIA-0489-86), p. 19.

(b) International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986.

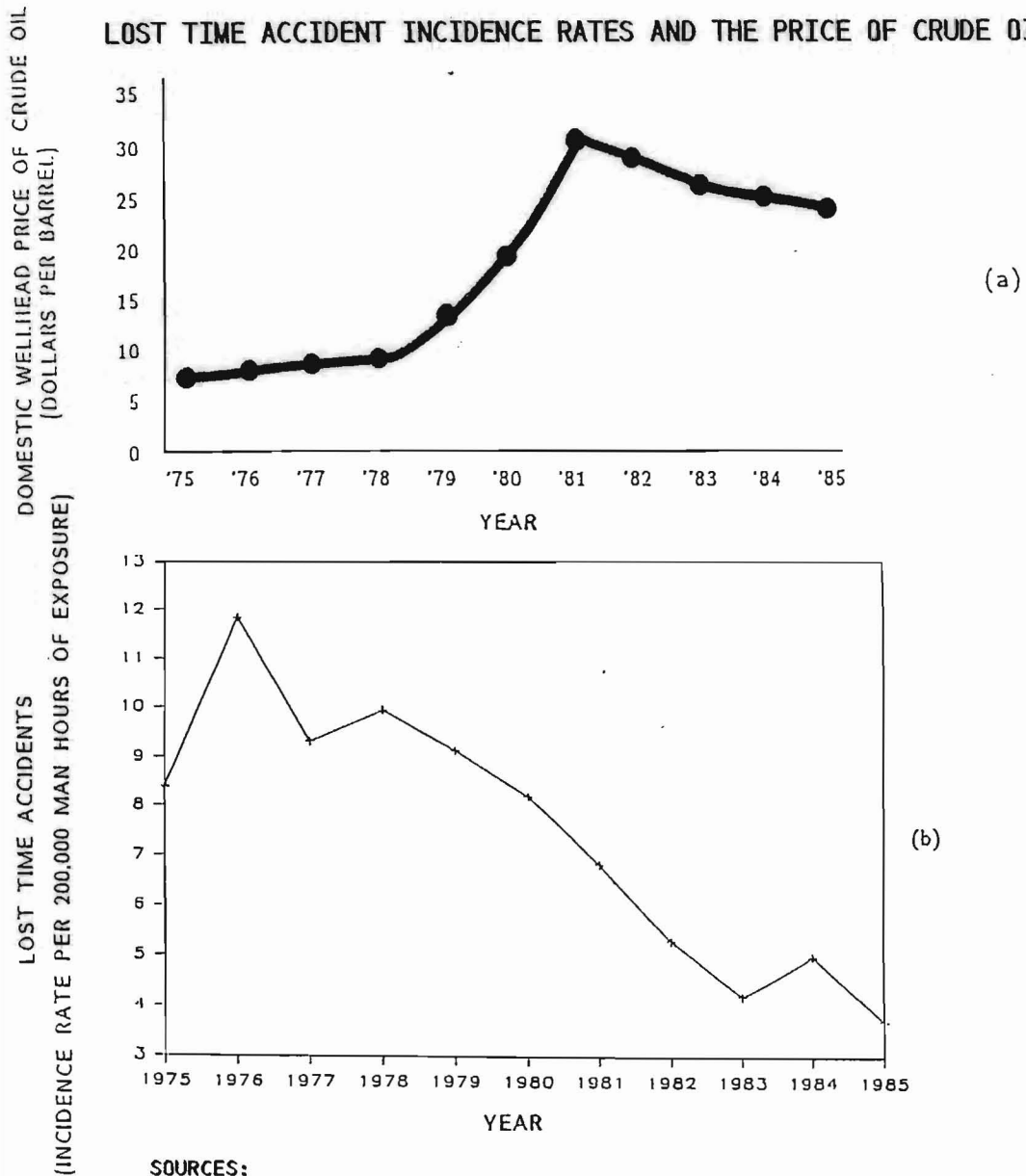
(c) Telephone Interview with Lt. Commander Moniz, United States Coast Guard, Office of Merchant Marine Safety, Washington, D.C., August 1986.

(d) Interview with Ulysses Cotton, Minerals Management Service, Offshore Rules and Operations Division, Reston, VA, September 1986.

NOTE: The accident data are reported by three separate collection systems. The International Association of Drilling Contractors data uses 12 hours to define a lost time accident. The Federal Agencies use 72 hours to define a reportable accident. The poor correlation between the price of oil and the accident data are discussed in Chapter 4.

FIGURE 8

LOST TIME ACCIDENT INCIDENCE RATES AND THE PRICE OF CRUDE OIL



SOURCES:

(a) Telephone Interview with the United States Department of Energy, Energy Information Administration, Washington, D.C., July 1987; and United States Department of Energy, Energy Facts, 1986 (Energy Information Administration, Washington, D.C.: DOE/EIA-0469-86), p. 19.

(b) International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986.

NOTE: Between 1978 and 1983 accident rates declined while the price of oil increased rapidly, peaked in 1981, and then declined. This indicates a poor correlation between accident data and the price of oil.

There would probably be an expected lag time between the price of oil dropping and a correlation emerging between OCS safety. However, the data reported here does not lend itself to a definitive conclusion. The ramifications of various scenarios will be discussed in Chapter 4.

Determining the influence that fluctuations in the price of crude oil exerts on OCS safety is also important in addressing the second hypothesis. When the price is high, more exploration occurs in frontier areas where innovative technologies frequently must be developed. Industry can afford to develop the equipment and techniques necessary to meet the safety regulations in these areas. BAST determinations are made by the regulators as the various choices between technologies warrant such decisions. A stable or increasing price of oil allows the economic feasibility issue of the BAST requirement to not be an overwhelming problem.

When the price of oil drops, such as from 1981 to 1985, industry can generally no longer afford to develop the prospects that require innovative and expensive equipment. There have been exceptions to this trend, such as the continuation of deepwater and Arctic drilling projects, but the financial outlays for these projects began long before 1981. The long lead times to first production also add to the risks and uncertainties of frontier-area oil and gas activities.¹³ Those risks and uncertainties are directly related to the price of oil. When ambitious projects are scaled down because of economic uncertainty, the riskier elements are generally the first to be eliminated. This tends to short circuit the BAST process in several ways. The status quo of routine operations is usually considered adequate by

industry so that the development of refinements in technology will be slowed dramatically.

Industry standards that have been accepted as BAST will also not improve because there is little incentive to change. The only changes instituted are typically due to potential cost savings rather than increased safety. In summary, therefore, lower oil prices appear to stifle or postpone BAST development in frontier and deepwater areas. Table 6 shows a comparison between LTA and fatality ratios for deepwater Gulf of Mexico OCS areas and for the entire OCS.

Exploratory wells drilled in water depths greater than 1,000 feet during 1984 and 1985 were used as a surrogate for areas that may have required the most BAST determinations to be made. The use of 1,000 feet as the criterion for deepwater is somewhat arbitrary. Definition of deepwater depends on several factors, including the organization that is asked. For example, the MMS definition of deepwater is 400 meters. However, this definition is in reference to leasing activity. The offshore oil and gas industry generally consider any work in water depths greater than 600 feet to be deepwater operations.¹⁴ It has been assumed that 1,000 feet is a water depth that a significant level of technological advancement was occurring in during the two years studied. It should be noted that, except for the LTA ratio in 1985, the deepwater ratios are larger than the entire population (Table 6). This indicates that deepwater areas may be more inherently dangerous than shallower areas. If the BAST requirement is being employed on the existing technologies in water depths less than 1,000 feet perhaps more attention needs to be paid to the deepwater areas.

TABLE 6

**COMPARISON BETWEEN ACCIDENTS AND FATALITIES IN
DEEPWATER GULF OF MEXICO AREAS AND THE ENTIRE OCS**

GULF OF MEXICO OCS AREAS WITH WATER DEPTHS GREATER THAN 1,000 FEET (a)					
YEAR	WELL STARTS	LTA	LTA RATIO	FATALITIES	FATALITIES RATIO
1984	47	16	0.34	4	0.08
1985	56	9	0.16	3	0.05

ENTIRE OCS ALL WATER DEPTHS (b)					
YEAR	WELL STARTS	LTA	LTA RATIO	FATALITIES	FATALITIES RATIO
1984	1,136	286	0.25	14	0.01
1985	1,040	334	0.32	15	0.01

SOURCES:

(a) Minerals Management Service, Federal Offshore Statistics: 1985 (Washington, DC: 1987, OCS Report 87-0008), p. 72, Table 65; and Interview with Ulysses Cotton, Minerals Management Service, Offshore Rules and Operations Division, Reston, VA, September 1986.

(b) Minerals Management Service, OCS Information Program, Vienna, VA, January 1988. (Obtained through a request to MMS for a data file from the Outer Continental Shelf Information System.)

NOTE: Except for LTA ratio in 1985, the deepwater data shows higher event incidence rates.

The above discussion also lends itself to an interesting policy question. Is it appropriate for the regulatory bodies responsible for implementing the BAST requirement to use a sliding scale approach when considering the economic feasibility of a particular technology? During boom periods, safety advances are routinely incorporated as BAST, but in periods of depressed prices should cost-cutting advances alone be considered BAST without an emphasis on safety?

The results of the recent past indicate that Government may be following such a policy through its implementation of the requirement. For example, the rescission of the Failure and Inventory Reporting System by MMS in 1982 demonstrated a willingness on the part of OCS regulators to allow the industry to cut costs even though safety may have also been reduced.¹⁵ It therefore seems that the BAST requirement, as currently instituted, is not achieving its stated goals.

The chief causes of accidents on the OCS are human error and the failure of equipment. Human error may be due to inexperience and carelessness among other factors. The failure of equipment may be a design, construction, or maintenance problem. Obviously, various combinations of these causal factors may result in the occurrence of an accident.

Accident rates could be expected to vary in a certain manner if a particular causal factor was primarily responsible. For example, given a scenario in which equipment is virtually infallible, human error would be the cause of nearly all accidents. A prediction could then be made that during times of high oil prices, when there is a high rig utilization rate with many new employees, inexperienced workers

might be the major cause of accidents. In time, proper worker training and increased field experience could be expected to bring the rate down. This would probably be true only as long as oil prices remained stable.

Under the same scenario, but with low or declining oil prices, a shrinking of the workforce could be expected. This would probably result in a pool of well qualified, experienced workers. The anticipated accident rate would then remain stable or even decrease. However, this scenario ignores some obvious contradictions that dictate national commerce. In a time of depressed oil prices the equipment would not receive the same level of maintenance as during boom periods. The same can probably be assumed for design and construction programs as exploration budgets shrink.

If it is assumed that the BAST requirement has not been working effectively and that design, construction, and maintenance problems are the primary causal factors, accident rates could be expected to remain high regardless of the price of oil. Even if experienced workers carefully conduct all operations, accidents caused by equipment failure would still occur. This scenario demonstrates the vulnerability of an equipment-oriented program such as BAST. Worker training and familiarization with new equipment is an important component of the human error problem. Having the best equipment is going to reduce accidents only if workers know how to operate it properly. Government procedures to determine BAST should include consideration of equipment training such as has been done with well control.

The determination of the economically feasible element of the BAST requirement is certainly a difficult task. OCS safety would

benefit most if the regulators could set safety standards or desired goals prior to deciding if a technology is economically feasible. Unfortunately, the implementation process of the policy limits the realization of those desired results. The objectives of BAST are written such that the economic viability of the technologies is the starting point and achieving the highest possible level of safety with those technologies is the stated goal.

Notes

1. International Association of Drilling Contractors, "Accident Safety Statistics Reports," 1975-1985. Houston, TX, 1986. The reporting percentages were calculated from the individual annual reports.
2. Telephone interview with Lt. Commander Moniz, U.S. Coast Guard, Office of Merchant Marine Safety, Washington, D.C., August 1986.
3. Interview with Ulysses Cotton, Minerals Management Service, Off-shore Rules and Operations Division, Reston, VA, September 1986.
4. Some items under discussion during 1985 were accident reporting requirements, casualty and injury data collection and analysis, joint accident investigations and reports, tension leg platforms, and an overall review of the MOU. Additional information may be found in: K.V. Feeney, "The Coast Guard's Offshore Safety Program," paper prepared for distribution at the Offshore Technology Conference, Houston, TX, 1985, p. 7 (typewritten).
5. Section 21(a) Report, "Joint Report by U.S. Coast Guard and Minerals Management Service on OCS Safety and Health Regulations and Technology," p. 27.
6. Ibid.

7. Minerals Management Service, Federal Offshore Statistics: 1985 (Washington, D.C.: 1987, OCS Report 87-0008), p. 12.
8. Section 21(a) Report, "Joint Report by U.S. Coast Guard and Minerals Management Service on OCS Safety and Health Regulations and Technology," pp. 26-27.
9. U.S. Department of the Interior/Minerals Management Service, "Oil and Gas and Sulphur Operations on the Outer Continental Shelf (OCS)," Federal Register 51, No. 52, March 18, 1986, 9322.
10. The streamlining of the reporting requirement was a recommendation in "Safety and Offshore Oil" that was reaffirmed by the Section 21(a) Report. It appears to be a natural target of the Reagan Administration's "minimal regulation" policy. Interestingly, it took until 1982 to promulgate the regulations from the Carter Administration's law (the OCS Lands Act Amendments of 1978) and in 1988 they may be substantially revised, to the point of being stripped of considerable regulatory power.
11. K.V. Feeney, "The Coast Guard's Offshore Safety Program," paper prepared for distribution at the Offshore Technology Conference, Houston, TX, 1985, p. 26 (typewritten).
12. Ibid, p. 31.
13. Oil and Gas Technologies for the Arctic and Deepwater (Washington, D.C.: United States Congress, Office of Technology Assessment Report OTA-0-270, 1985), p. 118.
14. Minerals Management Service, Gulf of Mexico Summary Report: October 1984 - June 1985 (Washington, DC: 1985, OCS Information Report MMS85-0083), p. 28.

15. U.S. Department of the Interior/Minerals Management Service, "Outer Continental Shelf (OCS) Order No. 5; Rescission of the Failure and Inventory Reporting System," Federal Register 47, No. 84, April 30, 1982, 18682-18683. For background information on the program and a justification of the decision to rescind it, see also U.S. Department of the Interior/ Minerals Management Service, Failure and Inventory Reporting System Summary/Analysis January 1980 - August 1981 (Washington, DC: 1984, OCS Report MMS 84-0032).

Chapter 4

CONCLUSIONS

The Problem

The problem addressed in this thesis concerns the trends that can be identified about offshore safety since the Outer Continental Shelf Lands Act Amendments of 1978. Has the regulatory structure described in this analysis improved safety during OCS oil and gas operations? Is the government capable of assessing best and safest technologies (BAST)? Has the implementation of the BAST requirement achieved its mandated goals in all OCS areas?

First Hypothesis

The issue raised by the first hypothesis is whether the trends identified in Chapter 3 indicate that OCS safety regulations have been effective in reducing offshore accidents. It should be emphasized that neither the MMS or the USCG officials contacted during this research identified specific safety reduction goals. The objective of improving safety was considered to be relative rather than absolute, which makes it difficult to determine if the regulations have been effective. However, based on the IADC data, which was the most consistently collected and presented set of information available, the industry improved its safety record during the study period. The trend shows a general reduction in LTA and the normalized annual LTA totals were substantially lower in 1985 than in 1975. Fatalities reported to the IADC also showed a decline between 1980 and 1983, but this trend is contradicted by a fatality rate increase in 1984 and 1985.

The IADC data are not without limitation, as demonstrated in Chapter 3. When compared with the government data, however, the IADC information is more reliable. The changes in reporting format from a voluntary to a mandatory system, and the sharp increases in LTA that resulted, jeopardize the utility of the MMS and the USCG data for a trend analysis throughout the study period. The fact that the fatality information from all three data sets more closely match is significant because the MMS and the USCG have always required the reporting of fatalities. One conclusion that can be drawn is that there is a need to establish a better accident reporting and safety information management system for the OCS. Improved cooperation and coordination between the industry and Federal regulators is clearly needed to increase safety on the OCS.

The proposed regulatory streamlining of the accident reporting requirements may prove to be a positive step towards achieving the goal of improved OCS safety information management. However, adequate safeguards must be incorporated into the new system that will ensure the accuracy and thoroughness of the reported accident data. The proposal that the Coast Guard will implement the program is fundamentally sound, given the long tradition of that agency in the area of maritime safety.

The possible use of a log such as that employed by OSHA has considerable merit, assuming the necessary data for offshore-specific events can be successfully generated. MMS input to the process should focus on providing causal data for events that occur during the actual exploration and development process, for which that agency has the most expertise.

Ultimately, the new safety information management system should be comprehensive in scope. Economic forces need to be factored into the equation so that the total safety picture can be assessed realistically. For example, the increase in MHE throughout the study period may be partly due to economics, but may also be caused by increased regulation. Exposure probably increases during equipment safety testing and emergency preparedness operations, but the additional MHE can be considered to reduce the risk to offshore workers.

It is also difficult to assess the impact that the oil price decline during the 1980s has had on accident rates. Long-term analysis of safety data and the price of oil will be needed to accurately determine the relationship between these two factors. Data from the period beginning in 1981 and ending in 1985 do not appear to indicate a discernible trend in this regard. Perhaps there is a "lag time" effect acting upon the safety and price relationships. The lag time effect may also manifest itself in the maintenance of equipment. Because the normalized MHE increased throughout the study period, LTA rates decreased, and fatalities decreased until 1983, the increase in fatalities during 1984 and 1985 could represent the lag time effect (whereby poor maintenance practices eventually lead to catastrophic failures).

The relationship between accident rates and exposure may also be particularly significant when compared with the price of oil throughout the study period (Figures 3 and 8). While the price of oil increased between 1975 and 1981, accidents decreased. Between 1981 and 1985, oil prices dropped slightly, and the approximate slope of the falling LTA curve in Figure 8 is steeper (indicating a more rapid decrease) than when oil prices were climbing.

One conclusion is that regardless of the price of oil, increased safety regulation will add to the total exposure time of each well drilled (Figure 9). This increased exposure will occur in addition to the variations in MHE caused by well depth or complex geology. Since the accident rates were found to decrease over the study period, the additional exposure time could be an indication that the regulatory approach is working. However, the short period of oil price decline precludes a definitive finding about this issue. In any event, it appears that whatever the price of oil, equipment failures will continue to occur. This may explain the dramatic increase in fatalities during 1984 and 1985. A longer study period would be needed to see if those years are normal variations or represent the beginning of a trend.

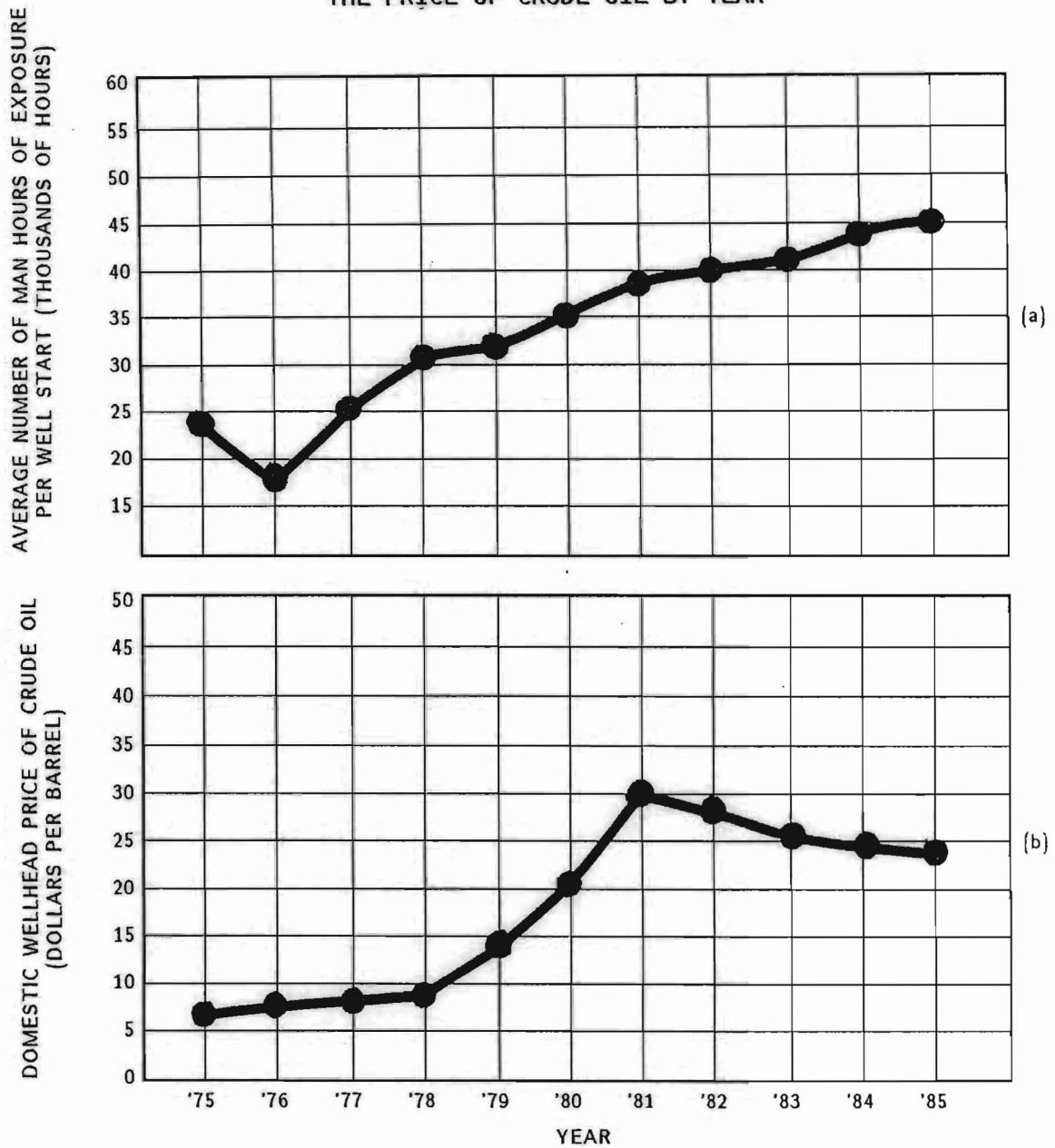
Second Hypothesis

The second hypothesis asserts that the BAST requirement has not successfully reduced the rates of deepwater accidents to the occurrence levels for the entire OCS. The two years in which deepwater data were compared to events in all water depths (Table 6) showed that these areas are not achieving similar rates of reduction in accidents and fatalities. While the brevity of the study period used in this analysis does not lend itself to a quantifiable conclusion in this regard, it is apparent that more attention should be given to deepwater technologies.

Several other general conclusions may be drawn from the information presented. The objectives of BAST are to ensure the application of economically viable technologies in the form of equipment, procedures, and systems that achieve the highest level of

FIGURE 9

AVERAGE MAN HOURS OF EXPOSURE PER WELL START AND
THE PRICE OF CRUDE OIL BY YEAR



SOURCES:

(a) International Association of Drilling Contractors, "Accident Safety Statistics Reports," Houston, TX, 1986; and Minerals Management Service, Federal Offshore Statistics: 1985, (Washington, D.C.: 1987, OCS Report 87-0008), p. 72, TABLE 65.

(b) Telephone Interview with the United States Department of Energy, Energy Information Administration, Washington, D.C., July 1987; and United States Department of Energy, Energy Facts, 1986 (Energy Information Administration, Washington, D.C.: DOE/EIA-0469-86), p. 19.

NOTE: International Association of Drilling Contractors data includes State Waters and Federal Outer Continental Shelf areas.

operating safety and reliability possible. The BAST program is supposed to assess and analyze technology needs and provide a framework to coordinate the exchange of technological information among regulators. MMS originally instituted an equipment-specific system for that purpose, the Failure and Inventory Reporting System, but cancelled it in 1982 due to a variety of inefficiencies.

More recently, MMS has implemented BAST through a system of headquarters and field committees. The committees identified and targeted problem areas that need technology assessment and possible research. This has resulted in several interesting annual reports on technology assessment but has not been particularly effective in assuring that OCS operations truly reflect BAST.

Before a given technology is considered BAST, it must be proven that requiring the use of the technology is economically feasible. This forces the regulatory bodies to place a monetary value on human safety and welfare. Is the government really suited to do that? It is difficult enough to determine best and safest, but to factor "economically feasible" into the equation seems to make the implementation of BAST unworkable. For both the USCG and MMS, the BAST requirement has been implemented through the incorporation of numerous standards, set by members of industry, trade groups, and the scientific and engineering community such as the American Petroleum Institute and the American Bureau of Shipping. At least this approach indicates that MMS and the Coast Guard recognize that the job is simply too big for them.

The "economic feasibility" provision of BAST also appears to have allowed the governmental agencies to administratively streamline

the regulatory structure at the expense of the intended purpose of the legislation that established the safety objectives. The minimal regulation policy of the present administration has effectively reduced the bureaucratic burden, but may have sent a confusing and inappropriate signal to the industry. While it is certainly true that the development of stringent evaluation and certification procedures is an expensive undertaking for regulators, the purpose of the BAST requirement was to balance increased costs to the industry with the improved safety that would result. The nation would be better served by a policy that passes along an additional cost burden to industry (and the public) in return for achieving a consistent method of assessing and implementing the best available and safest technologies on the OCS.

If there were no BAST requirement, the industry would have determined its own safety-to-cost ratio by default. The implementation procedures of the BAST requirement dictated that this actually happened to some degree through the regulatory process. While such bureaucratic activity has probably enhanced OCS safety to some extent, the opportunity for a self-policing industry may have been lost. Having the best equipment is going to reduce accidents only if workers have the knowledge to operate it properly and are self-motivated to do so.

Since the government has implemented a program that accepts the industry standards, future regulatory efforts under the BAST requirement should focus on training and other methods of instilling the motivation necessary to achieve continued safety improvements on the OCS. An award and reward approach may be one such method of implementation, in which the government requires training programs, evaluates performance, and provides awards and other incentives to the

industry to police itself. Therefore, Congress should consider separating the human element from equipment in future OCS safety legislation. In this way, government regulators could better differentiate between worker training and deepwater technologies, which are two critical outstanding issues identified in this thesis.

Appendix I

THE ROTARY DRILLING CONCEPT, NOMENCLATURE, AND POTENTIAL OFFSHORE HAZARDS

When operating offshore, the type of rig used and the way it is moved to and from the drilling location depends on whether the project is an exploration or a development well. If the well is exploratory, particularly in a frontier area, some type of mobile offshore drilling unit (MODU) will be used. MODUs typical of operation on the OCS are jack-ups, semisubmersibles, and drill ships.

Jack-up rigs are built so that they float when being moved to or from location. Because these rigs are relatively unstable while under tow, they are subject to a disproportionately high incidence of accidents during rig moves. Once at the drilling site, the legs are lowered down to the seafloor. The platform is then raised or "jacked-up" on the part of the legs that remain above the water. The higher the rig is jacked up, the less stable it becomes. This can be of particular concern in areas experiencing large wave heights that dictate the rig must be jacked up a considerable distance from the water surface. Current technology limits the practical application of jack-ups to water depths approximately 350 feet in depth.¹

Semisubmersibles consist of two underwater displacement hulls upon which the platform floats while being towed to or from location. Once on station, the lower sections of the hulls are flooded enough to partially submerge the unit so that the focus of buoyancy is beneath the surface of the water. Therefore a semisubmersible floats, but not really on the water's surface, providing maximum stability in rough seas characteristic of deepwater. It was the accidental flooding of a

hull section that was determined to be responsible for causing the Ocean Ranger to list, and ultimately sink off the coast of Newfoundland in 1982 resulting in 84 fatalities.

The hull shapes of drill ships are essentially identical to those of many other oceangoing ships. The presence of drilling equipment requires several modifications to these vessels that make them distinctive. Major design differences include the moon-pool, an opening mid-ship through which drilling operations are conducted, and ballasting to accommodate the installation of the drilling rig above the moon-pool.² Because drill ships are self-propelled they are the most mobile of all the MODUs and are generally employed to drill exploratory wells in remote deepwater areas.

There are several other types of MODUs in addition to those previously described, but they are not commonly used for exploratory drilling on the OCS. Although there are certain obvious differences involved in the operation of these three kinds of MODUs, much of the basic equipment and many of the techniques used in the modern rotary drilling process are surprisingly similar. All drilling rigs require power systems that employ some combination of diesel engines and electric motors to drive the rig equipment. These are referred to as the compound and may consist of either raw mechanical power or electrical generators. The rig equipment includes: the hoisting and pipe-handling system, the rotary drilling equipment, and the circulation system. Each of the major components of these systems will be described in turn.

The hoisting and pipe-handling system supports the rotary drilling equipment over the hole and moves sections of the drill string

and casing from storage racks to the hole. The basic parts are: the tower-like derrick or mast, the blocks and drilling line, the drawworks and catheads, pipe-handling equipment, and storage racks. The derrick represents potential height-related hazards to personnel, both while on the structure from falls, and to those working on the rig floor from falling objects. Either the crown block, the traveling block and hook, or the drilling line could pose a hazard if they were to fail under a given load, particularly during those operations that would involve many workers being on the rig floor at once. The drawworks and catheads, being revolving mechanisms, are inherently high in danger resulting from human error. Operating either of these pieces of equipment in the presence of the environmental variable rain, increases dramatically the potential for injury.

Pipe-handling equipment, such as tongs and chains, are often dangerous because of the precision timing and interaction required by operating personnel. Inexperience, carelessness, and fatigue each play a major role in determining the safe use of such equipment. Storage racks are typically a source of crushing type accidents and are often more dangerous on offshore rigs because of the close proximity to other working locations that storage areas must be in relative to land-based rigs.

Although there are parts too numerous to mention, the essential components of the rotating system are described in the following discussion. The swivel is a complex piece of equipment consisting of a handle-like bail that fits inside the hook at the bottom of the traveling block. The swivel itself sustains the weight of the drill string, permits the string to rotate while maintaining a pressure-tight seal

and passageway for drilling fluid to be pumped down the inside of the drill string.³ A hose attached to the side of the swivel called the rotary hose, allows drilling mud to enter the swivel. Fastened immediately below the swivel is a square or hexagonal hollow pipe called the kelly. The kelly is typically about 40 feet in length and, like the swivel drilling fluid, is also pumped through it, on the way to the bottom. The reason the kelly is four- or six-sided is because it serves as a way of transferring the rotating motion of the rotary table to the drill string. The kelly fits inside a corresponding square or hexagonal opening in a device called a kelly bushing, which is part of the rotary table.⁴ The rotary table also contains a master bushing into which the kelly bushing fits, and is powered either off the compound or by an independent electric motor. As the master bushing rotates, the kelly bushing also rotates, which in turn rotates the kelly. When the kelly is picked up or disconnected, the kelly bushing is also removed from the master bushing which then may accommodate a wedge-like device known as the slips. A set of slips is tapered and lined with strong teethlike gripping elements that, when placed around the drill pipe, keep it suspended in the hole when the kelly is disconnected or broken out. The kelly must be broken out each time a length of drill pipe is added to the drill string as the hole is drilled deeper or when the pipe is run in or out of the existing hole in a process referred to as tripping.

Drill pipe is steel tubing that comes in lengths of about 30 feet called joints. Each joint is slightly different in length so that when pulled in sets (typically of three joints) called stands, the threaded portions, known as tool joints, are not all at the same

height. This allows for a tighter fit when stacked in the derrick pipe racks where space is a valuable commodity. The drill collars are heavy-walled tubulars located immediately above the bit, that apply most of the weight necessary to enable the bit to drill. The term drill string refers to the kelly, drill pipe, drill collars, and any other components located between the top drill collar and the bit, in a subsection of the drill string known as the bottom hole assembly (BHA). It should be emphasized that the entire drill string is hollow to allow for the passage of pressurized drilling fluid. The configuration of the various components used to make up the BHA may be altered whenever the drill string has been tripped out of (removed from) the hole. Many of the innovative technologies that have been developed to correct hole problems or to drill directionally are simply variations of the BHA. Also, much of the measurement while drilling (MWD) technology involves the use of mud pulsing motors located within a drill collar in the BHA. MWD provides real time data acquisition capability and is considered to be an extremely valuable tool, especially in frontier drilling applications.

Circulation System

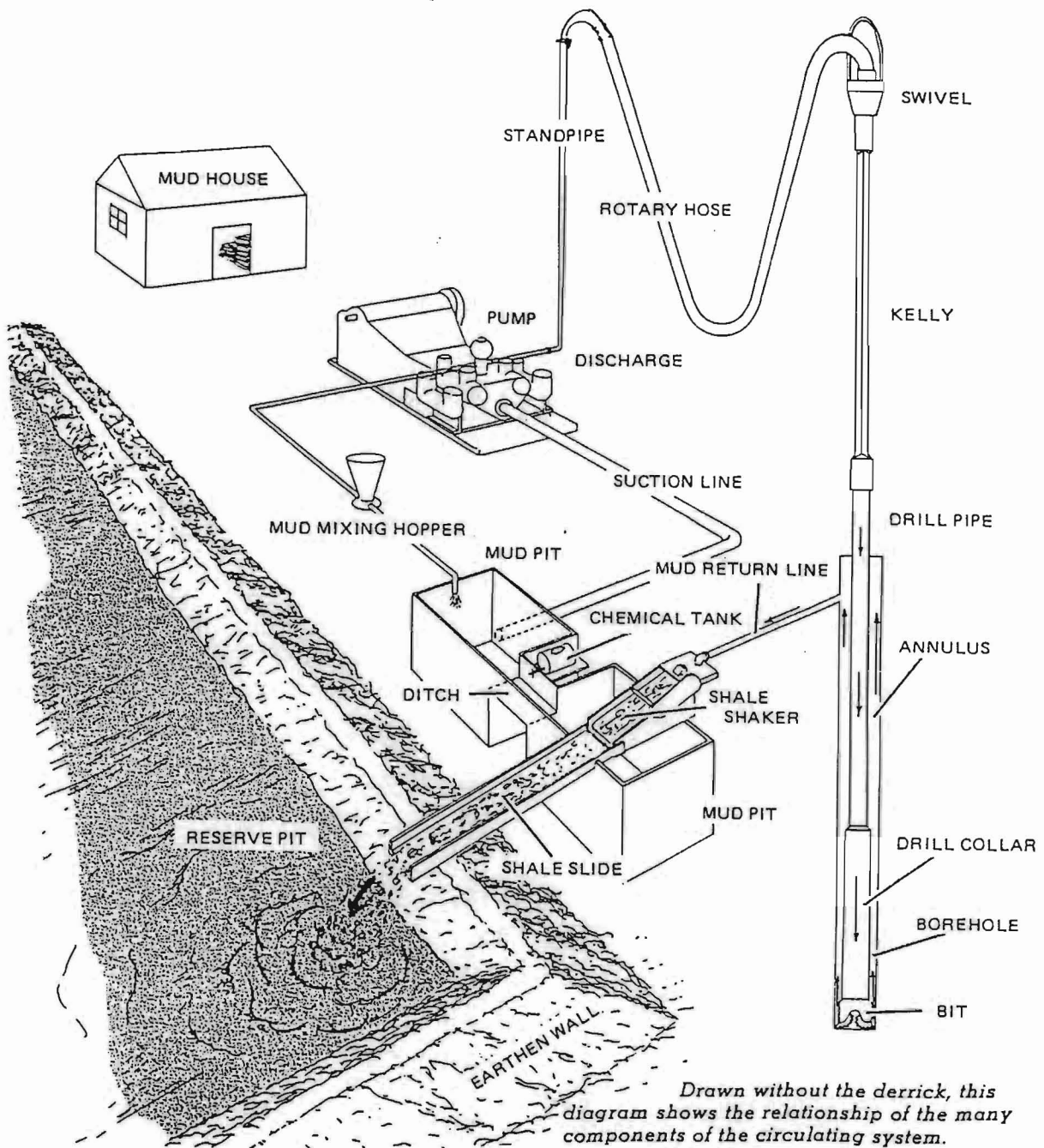
The circulation system is comprised of drilling fluid and the equipment needed to circulate the fluid throughout the well. The fluid, known as mud, is custom-designed for each hole, but generally consists of water, clay, weighting materials, and lesser amounts of various other additives.

Mud has two main functions: (1) carrying rock cuttings made by the bit to the surface; and (2) holding back natural underground pressures in order to prevent gas, oil, or water in the rock formations

from entering the borehole. A hole full of drilling mud exerts hydrostatic pressure in a manner similar to a swimming pool full of water exerting increasing pressure at greater depths. That is why some people's ears hurt when they dive to the bottom of the deep end in a pool. The pressure exerted by the mud in the borehole is analogous to the water in the pool in that it also increases with depth and can therefore be used to contain the pressures exerted by the formations on the borehole. These are the underlying principles of well control, which is an area of the drilling operation that is probably the most critical for safeguarding against catastrophic accidents.

The individual components that make up the circulation system are shown in Figure 10. Generally, the mud is mixed through a hopper into holding tanks called mud pits. The mud pump takes in mud from the pits and discharges it under pressure into a vertical steel pipe referred to as the standpipe that is mounted on one leg of the mast or derrick. The pressurized mud then flows through a very strong, reinforced rubber hose called the rotary hose or kelly hose and into the swivel. From here, as discussed earlier, the mud travels down the hollow-stem kelly, drill pipe, and drill collars; and exits at the bit through the three jet nozzles. It then does a sharp U-turn and heads back up the hole in the annulus, which is the space between the outside of the drill string and the wall of the hole.⁵ Mud leaves the hole through the mud return line and passes through cleaning equipment which removes rock cuttings, silt, and sand. Ideally, the mud circulation process is a closed system where the mud is circulated through the hole many times. Periodically, additions of various mud components are made to make up for losses or to change the properties of the mud to control

FIGURE 10
THE CIRCULATION SYSTEM



SOURCE: Ron Baker, A Primer of Oil-Well Drilling, 4th ed. (Austin, TX: Petroleum Extension Service, University of Texas at Austin in cooperation with the International Association of Drilling Contractors, Houston, TX, 1979), p. 43.

the changing down-hole environment as new formations (and pressures) are encountered. Because mud is such an important part of the drilling operation, specialists design the equipment and plan ingredients for the mud. Rig personnel continuously monitor the circulation system, and with the help of auxiliary mud-cleaning equipment provide the first line of defense against blowouts. The circulation system is closely tied to the well control system and is, in fact, the primary method of preventing the intrusion of formation fluids into the well bore.⁶

A hole full of drilling fluid that is properly conditioned and has a mud weight sufficient to exert slightly greater pressure on the formation than is being exerted on the bore hole is ideal and is known as a balanced drilling situation. There is a fine line between achieving balanced drilling and losing circulation to the formation. This may occur at any depth, wherever the total pressure against the formation exceeds the total pressure of the formation, and the openings in the formation are about three times as large as the largest particles found in quantity in the mud.⁷ Lost circulation can be a very costly problem and serious efforts are made to prevent its occurrence including making a diligent attempt at maintaining balanced drilling.

However, the danger of formation fluids intruding into the well bore also increases as mud weights decrease. Once formation fluids enter the well bore a potentially dangerous condition referred to as a kick is underway and must be properly alleviated to avoid a loss of well control. The first warning that a kick has occurred is usually an increase in the (returning) flow rate of drilling mud that leads to a gain in pit volume. Or, mud may flow out of the well even when the pumps are not in operation. Rig personnel are responsible for

spotting these sometimes subtle anomalies and taking preventative action. This is an important factor to remember when considering legislated safety regulations. Intangibles, such as personality, mood, and training aptitude may all come into play in the split second timing frequently required to maintain safe operations. It is at this point that the second line of defense against the loss of well control is employed. The two basic types of blowout preventers (BOPs) are annular and ram. They are arranged in what is known as a BOP stack and together with a series of valves, called the choke manifold, make up the well control equipment. BOPs are large high pressure remotely controlled valves that when closed, form a pressure-tight seal at the top of the well and prevent the escape of fluids.

The annular preventer is usually mounted at the very top of the BOP stack. It gets its name because when activated, it seals off the annulus between the drill pipe or kelly and the side of the well bore.⁸ The annular preventer may also be used to seal off an open hole, a condition that exists periodically throughout the drilling operation, such as when the drill string has been tripped out of the well to change the bit. Below the annular preventer in the BOP stack is a series of up to four ram-type preventers, so called because the rubber-faced blocks of steel are rammed together to seal off the well, much like a couple of fighting rams butting heads.⁹ Of the ram-type preventers there are typically two sets of blind rams, which seal off the open hole, and two sets of pipe rams, which have a semicircular section cut out to allow sealing of the hole while drill pipe is in use. Usually, only the annular preventer will be closed when the well

kicks, but should it fail, or should it be necessary to use special techniques, the ram-type preventers are used as a backup.¹⁰

On fixed platforms, barges, and jack-up rigs the BOPs are attached to the top of the well beneath the rig floor (as on land-based rigs). On floating rigs the preventers are mounted on the wellhead at the seafloor which creates some additional pressure control problems that must be mitigated.

Closing off the flow within the well with the BOPs is only the first step that must be taken to successfully dissipate or kill a kick. In order to resume drilling, the kick must be circulated out and mud of the proper weight to again achieve a balanced condition must be pumped in to replace it. Therefore, the choke manifold is used to maintain a relatively constant pressure while the kick is circulated out. The valves start out being nearly fully open and are slowly closed as the heavier kill weight mud is pumped down the drill string while the kick moves up the annulus. In simplified terms, the choke opening is continuously reduced in size by an amount that retains just enough back-pressure to allow the mud that has been cut by the kick to move up and out of the hole but prevents further entry of formation fluid into the well bore.

There are several differences in the use of chokes depending on whether the BOP stack is on the surface or at the seafloor. Generally, the choke operator must compensate for the hydrostatic pressure present due to the water depth after the kick has reached the seafloor when a subsea BOP stack is in use. Special training that includes the use of simulators is required by MMS to prepare drilling crews for such activities. There are many other items of equipment needed to drill

wells on the OCS. However, the previous description should provide a sound basis from which to thoroughly review offshore safety.

Notes

1. Ron Baker, A Primer of Oil-Well Drilling, 4th ed. (Austin, TX: Petroleum Extension Service, University of Texas at Austin in cooperation with the International Association of Drilling Contractors, Houston, TX, 1979), p. 20.
2. Safety and Offshore Oil, Report of the Committee on Assessment of Safety on Outer Continental Shelf Activities, Marine Board Assembly of Engineering, National Research Council, by George F. Mechlin, Chairman (Washington, DC: National Academy Press, 1981), p. 199.
3. Baker, Primer of Oil-Well Drilling, p. 37.
4. Ibid, p. 38.
5. National Research Council, Safety and Offshore Oil, p. 44.
6. Magcobar Division, Oilfield Products Group of Dresser Industries, Inc., Drilling Fluid Engineering Manual (Houston, TX: By Sawyer Printing Co., Inc., 1977), p. 16-1.
7. Ibid, p. 14-1.
8. National Research Council, Safety and Offshore Oil, p. 48.
9. Ibid.
10. Ibid.

Appendix II

GULF OF MEXICO OCS REGION, ACTIVE NOTICE TO LESSEES AS OF DECEMBER 1985

No.	Title	Date
85-9	Corpus Christi District Address, Office Hours, and Phone Call Procedures	12/2/85
85-8	Minimizing Oil and Gas Structures in the Gulf of Mexico	11/26/85
85-7	Lafayette District Address, Office Hours, and Phone Call Procedures	8/12/85
85-5	Lake Jackson District Address, Office Hours, and Phone Call Procedures	4/15/85
85-3	Houma District Address, Office Hours, and Phone Call Procedures	2/14/85
85-2	Effect of Drilling Window Approvals	2/4/85
84-5	Establishment of Corpus Christi District Office	11/21/84
84-3	Lake Charles District Address, Office Hours, and Phone Call Procedures	9/12/84
84-1	Outer Continental Shelf Development Operation Coordination Documents	2/10/84
83-5	Metairie District Office Hours and Phone Call Procedures	10/31/83
83-3	Outer Continental Shelf Shallow Hazards Requirements for the Gulf of Mexico OCS Region	9/7/83
75-3	Revision No. 1 Outer Continental Shelf Cultural Resource Requirements for the Gulf of Mexico OCS Region	10/1/82
82-8	Interim Minimum Requirements for Marking of Equipment	8/30/82
82-7	Clarification of Requirements of Subparagraph 5.7, Safety Device Training, of OCS Order No. 5, "Production Safety Systems"	8/13/82
82-5	Suspension of the Failure and Inventory Reporting System (FIRS) Program Reporting Requirements	4/20/82
82-4	Reorganization Announcement	4/19/82
81-5	Minimum Requirements for Clearance of Location After Plugging and Abandonment of Wells	4/24/81
81-1	Termination of Report - Major Well Shut Ins	2/2/81
80-12	FIRS Reporting Information	12/17/80
80-9	Reporting of Pipeline Damage	10/6/80
80-8	Annual Review of Field Rules	7/30/80
80-6	Outer Continental Shelf Environmental Report Guidelines for the Gulf of Mexico OCS Region	6/2/80
80-5	Planning and Conduct of Operations in the Vicinity of Existing Pipelines and Other Hazards	5/29/80
79-13	Furnishing Food, Quarters, and Transportation to USGS Personnel	12/21/79
79-10	Relief from Compliance with Certain Requirements of OCS Order No. 13	10/25/79

No.	Title	Date
78-5	Royalty Payment on Vented and Flared Gas and Gas or Oil, or Both, Leaked, Spilled, or Used in Producing Operations	3/20/78
78-4	API RP 14C, Second Edition, January 1978	4/13/78
78-3	Information Available on Well No. 2, OCS-G 3111	3/29/78
78-2	Value of Natural Gas for Royalty Purposes	6/1/78
78-1	Value of Natural Gas Liquids for Royalty Purposes	6/1/78
77-5	Revised Outer Continental Shelf Order No. 2	7/19/77
77-4	Secretarial Order No. 2974	4/4/77
77-2	Information Available on Well No. 3, OCS-G 1029	3/1/77
76-9	Information Available on Well No. 4, OCS-G 2177	11/10/76
76-6	Revision of Section 4.D(4), Training, OCS Order No. 8	10/21/76
76-4	Annual Field Names Master List Revision	9/7/76
76-2	Price Determination for Natural Gas Sales Authorized by FPC Opinion 699-H	1/27/76
76-1	Release of High Resolution Geophysical Data Offshore Louisiana and Texas	1/9/76
75-14	Acceptance of Dipmeter Directional Surveys on Vertical Wells	12/23/75
75-13	Release of High Resolution Geophysical Data Offshore Louisiana and Texas	11/6/75
75-9	Guidelines Related to OCS Order No. 11 Provisions on the Flaring of Casinghead Gas	5/13/75
75-4	East Flower Garden Bank Monitoring Requirements	2/21/75
75-3	Minimum Geophysical Survey Requirements to Protect Cultural Resources	1/20/75
75-1	Reporting of Fires and Serious Accidents	1/2/75
74-25	Addendum to Our Notice No. 74-19	12/5/74
74-23	Change in Area of Jurisdiction for New Orleans District Office Metairie, Louisiana	11/6/74
74-22	Change in Area of Jurisdiction for Lafayette District Office Lafayette District	11/6/74
74-21	Establishment of Houma District Office Houma, Louisiana	11/6/74
74-19	Relocation of Texas District Office to Freeport, Texas	10/18/74
74-18	Establishment of Lake Charles District Office Lake Charles, Louisiana	10/18/74
74-17	Subsequent to Biological Survey Requirements	8/12/74
74-16	Release of High Resolution Geophysical Data Offshore Louisiana and Texas	10/30/74
74-15	Issuance of Approved Maximum Efficient Rates of Production for Oil and Gas Reservoirs	8/12/74
74-13	Subsequent to NTL No. 74-11 "Hydrogen Sulfide in Drilling Operations"	5/29/74
74-12	Biological Survey Requirements	5/15/74
74-8	Potential Unstable Sediment Conditions in the Mississippi Delta Area	3/29/74
74-7	Analysis Results of Produced Waste Water Discharged into Gulf of Mexico Waters	3/25/74
74-6	Disposal of Produced Sand	3/25/74

74-5	Reasons for Shut-in Status of Oil and Gas Wells	2/7/74
74-4	Amendment to Notice 73-10 Issued December 21, 1973	1/29/74
74-3	OCS Order No. 11	4/18/74
74-1	Applicability of OCS Orders Nos. 2 and 4 to OCS Leases Issued off the Coasts of Mississippi, Alabama, and Florida	1/4/74
73-10	Subsurface Safety Device Requirements for Unattended Wells Open to Production	12/21/73
73-9	Hydrogen Sulfide in OCS Operations	12/21/73
73-8	Allocation of Royalty Oil	10/29/73
73-7	Amendment to Instruction on Run Tickets	10/16/73
73-5	Frequency of Sewage Effluent Testing	10/29/73
73-4	Special Security Handling of Well Logs and Data	6/1/73
73-3	The Use of Polychlorinated Biphenyls (PCB's)	2/16/73
73-1	OCS Order No. 5	1/18/73
72-12	Disposal of Produced Waste Water Other than into Gulf of Mexico Waters	12/11/72
72-11	Shut-In Completions	10/13/72
72-9	First Safety Alert Notice	9/22/72
72-8	Field Names	8/30/72
72-7	Designation of "Gulf Coast Region" changed to "Gulf of Mexico Area," and title "Regional Oil and Gas Supervisor" changed to "Area Oil and Gas Supervisor"	7/12/72
72-6	Approved Maximum Production Rate Schedules	6/29/72
72-5	Monthly Report of Operations (Form 9-152) and Report on Gas Flaring	4/21/72
72-4	Casing Design Program	4/7/72
72-3	Interim OCS Order No. 11	4/5/72
72-2	OCS Order No. 5	3/28/72
72-1	Approved Maximum Production Rate	2/22/72
71-5	Information Available on Well No. 2, OCS-G 1615	12/10/71
71-4	Proper Conditioning of Drilling Fluids	9/23/71
71-3	OCS Order No. 12	8/20/71
71-2	OCS Order No. 8	7/16/71
71-1	Transmittal of Working Draft of the Inspection Forms for Both Drilling and Producing Operations	5/27/71
70-2	Interim Oil and Gas Production Rates	12/7/70
70-1	Reporting of Oil Slicks	2/5/70
69-2	OCS Orders No. 1 through 10	9/4/69
69-1	Conditions of Approval to Drill Outer Continental Shelf - Off Louisiana	8/28/69
61-1	Lack of Proper Wellhead Identification	7/11/61

NOTE: Obtained from: Gulf of Mexico OCS Regional Office, Metairie, LA, 1986.

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